AMERICAN ENGINEER AND RAILROAD JOURNAL.

Formerly the RAILROAD AND ENGINEERING JOURNAL.

(ESTABLISHED IN 1832.)

THE OLDEST RAILROAD PAPER IN THE WORLD.

The American Railroad Journal, founded in 1832, was consolidated with Van Nostrand's Engineering Magazine, 1887, forming the Railroad and Engineering Journal, the name of which was changed to the American Engineer and Railroad Journal, January, 1893.

PUBLISHED MONTHLY AT No. 47 CEDAR STREET, NEW YORK.

M. N. FORNEY, . . . Editor and Proprietor.
FRANK J. FRENCH, . . . Business Manager.

Entered at the Post Office at New York City as Second-Class Mail Matter.

SUBSCRIPTION RATES.

Subscription, per annum, Postage prepaid	$3 00
Subscription, per annum, Foreign Countries	3 50
Single Copies	25

Remittances should be made by Express Money-Order, Draft, P. O. Money-Order or Registered Letter.

The paper may be obtained and subscriptions for it sent to the following agencies:
Chicago, Post Office News Co., 217 Dearborn St.
London, England, Sampson Low, Marston & Co., Limited, St. Dunstan's House, Fetter Lane, E. C.
Berlin, Germany, W. H. Kühl, 73 Jäger St.
Paris, Bandry et Cie., 15 Rue des Saints-Pères.

NEW YORK, SEPTEMBER, 1895.

EDITORIAL NOTES.

THE final step has at last been taken, and the *St. Louis* has earned the mail-carrying contract with the United States Government, in accordance with which she was built. The trial in the English Channel last month has placed her in the front rank of ocean liners, and already there are predictions that next year she will prove a record-breaker. The record may be broken, but it will be incidentally to her regular service, and not because the company will abandon its present position of placing safety and comfort in a higher rank than speed. In our news columns we publish a brief account of the trial over the measured course.

ONE of the recent notable events in locomotive practice is the introduction of a locomotive with a single pair of driving-wheels upon the Bound Brook Line between New York and Philadelphia, for hauling the fast express trains. The train running west, to which this engine is assigned, has a schedule time of two hours from New York to the Reading Terminal, including the ferriage and three stops. The train is composed of six cars. The starting is done with as much apparent ease as with the ordinary eight-wheeled engine, and the maintained speed is in several places from 47 to 49 seconds to the mile.

DEAD WEIGHT.

THE improvements in the manufacture of steel which were made thirty or forty years ago, and the general introduction of rails and locomotive tires made of that material, while adding very much to the resources of railroad engineering, seem to have been productive of more or less recklessness among railroad engineers and managers in permitting what probably was a needless increase in the weight of rolling stock. It was found that the improved material would carry much greater loads than iron would without any destructive result, and those who had control of the design and construction of cars and engines seemed to feel that that fact was a license to make them as heavy as they liked, and that no restraint had to be exercised over any addition to the dead weight of such vehicles and machines. Like an imprudent or ignorant person falling heir to a fortune, the need for economy no longer seemed to exist. As a sequence to these improvements in the production of steel, there also came a great increase in wealth and prosperity, and the love of comfort and luxury was correspondingly developed; and—more important still—the capacity to pay for it was acquired by many people who never had it before. Railroad companies and their satellites were not slow to recognize this newly developed taste and capacity, and luxurious cars were soon furnished to supply the demands. With wealth came a love of ostentation and display, and, as a consequence, cars were increased in gorgeousness, and, unfortunately, the heaviness of their decoration and actual weight both increased correspondingly. During this period both freight and passenger cars were steadily increased in weight, the one class from the causes indicated, the other owing to the enormous additions to the volume of traffic, and to the fact that great economies could be realized by increasing freight trainloads, especially when these were hauled long distances. This growth was accompanied by an evolutionary process of the destruction of the weak cars and their parts by those which were strong. When a part broke, the natural and common-sense sequence was to make it stronger, which to the ordinary mechanical mind means to make it heavier. Now such an increase in weight may be essential, and it may not be. Possibly an intelligent investigation might show that strains could be diminished by a different form or forms of construction, or by changing the distribution or quality of the material. Whether expressed or not, the principle was acted upon that if you make anything too strong no one will ever find it out, but if it is too weak the fault will be soon apparent, and so weight was added to one part after another, until now cars and locomotives are veritible engines of destruction to themselves and the track they run on. It is now a process of the survival of the biggest and the heaviest, and, as in nature, that which is weak and defective succumbs.

Perhaps some profitable inferences might be drawn—as the preachers say—"in this connection" by the evolutionary process which has been going on in parallel lines and periods with the increase in dimensions and weight of rolling stock. We refer to the science and art of iron and steel bridge building. Iron bridges began to be generally used about the time that the improvements in steel making, already referred to, were introduced. Now there are two limitations from which a constructor of a bridge cannot escape. These are, first, that if it is not strong enough it will break down; and, second, that if superfluous material is put into it, it will add almost proportionately to its cost. The fall of a bridge is generally attended with a penalty of its own, and as such structures are usually built by contract, the profits of the contractors bear an inverse relation to the cost of the work. There were, therefore, the strongest possible inducements to make bridges strong enough, and next to avoid the use of any superfluous material in their construction. The result has been that the very highest order of engineering science and skill has been called into requisition in designing and building them, and we have the curious anomaly that the static structures on railroads, or those in which dead or useless weight would have no injurious effects—excepting on the first cost and that the extra weight would have to be supported—are made as light as possible, whereas those who are responsible for it seem to be indifferent about the weight of the machines which have motivity, and

which are constantly exerting a destructive action on themselves and their bases of support. It must be admitted that it is impossible to apply exact scientific methods to the design of the parts of a freight car, for example, or to determine their proportions by mathematical calculations to anything like the extent that these are employed in bridge engineering. Of course it is true that, to a very great extent, the design and construction of cars and locomotives is and must be based on empiricism to a much greater extent than the planning and building of bridges is. A bridge must be made to carry definite and generally known loads, and bear strains which are calculable, excepting, perhaps, those which are imposed by master mechanics by the improper counterbalance of locomotives. Doubtless a designer of a locomotive, if he knows enough, could calculate how much strain a rocking shaft, say, would stand without breaking, but then he don't know how much power or how great a force may be required to move a slide-valve, especially if its surfaces are not properly lubricated. If by observation he finds that shafts of a given diameter do not break, he is apt to conclude that they are of the proper size and weight. In this conclusion he occupies a safe position; but if he carried his empirical methods a little further, he might find that other smaller rocker shafts have also endured the service in which they have been used, and that the larger ones which failed did so owing to being made of inferior material. There is such a thing as scientific empiricism, and if we take Herbert Spencer's definition that scientific knowledge is only "*definite* knowledge," then as soon as empiricism becomes definite it becomes scientific.

A great difficulty which stands in the way of bringing about any great reform in the weight of rolling-stock is that railroads are and necessarily must and should be conducted as business enterprises. It, of course, would be very erroneous to undervalue the kind of ability which is required to make such enterprises succeed, and it is very difficult to define or to apprehend just exactly what the peculiar faculties are which enable men to conduct such schemes successfully, nor will it be attempted here; but attention will be called to the common deficiency among men of that kind of not being able to comprehend the value of mechanical skill, especially skill in designing machinery. Reference is not made here to inventive ability, although somewhat of that capacity always goes with skill in designing machinery when it is of a high order. What is meant is merely the capacity for shaping and adapting and proportioning the various component parts of machinery to the purposes for which they are intended. The differences in the character and quality and value of this kind of ability is comparable to that which differentiates the colored man who handles a whitewash brush from the tradesman who does kalsomining, and he in turn from the sign and decorative painter, and they again from artists of low degree; and going still farther, the quality and value of their work is differentiated from that of the great men in the profession. This difference may be and often is expressed in dollars and cents in the price of pictures. At the one extreme, the value of a day's work is represented by a dollar or two; at the other, by hundreds of dollars. Most railroad presidents and managers can be made to understand the difference in the value of a daub and the work of an artist of talent or genius, but not many of them can be made to apprehend that there is an analogous difference between the designs of a mechanician of first-rate ability and the work of persons of ordinary skill. Most railroad presidents and managers, when they buy pictures for their houses, either want the name of a great artist or the opinion of a competent critic as a guarantee of the quality of the work; or, if they are building a house or a railroad station, they employ an architect; but they will entrust the design of rolling stock —especially of cars—to persons of the most ordinary incapacity, apparently without a suspicion that the character of the design will not be better than the ability of the designer. It may be said unhesitatingly that there is and always will be a corresponding difference between the work produced by a botch workman and a master in mechanical design that there is between the pictures of a "duffer" in art and those of great artists.

In the reform of any evil the first step is to ascertain its exact character and extent. To do this the problem of reducing the weight of ordinary box freight cars might be approached by an analytical investigation—that is, the investigator might take the standard cars of each of a half-dozen different railroads, and getting first their correct aggregate weight, could then weigh each part separately and make an accurate drawing of it. These should then be arranged so as to facilitate comparison not only of weight, but of construction. The first thing which would probably appear would be that some one or more of the same parts used on different roads is either lighter or heavier than that used on other roads. In Artemus Ward's significant phraseology, the inquiry would then be in order, "Why is this thus?" If the Boston & Albany Railroad Company can use a much lighter centre-plate than the Erie Company does (we do not know that they do), why may not the lighter one be substituted for that which is heavier? The substitution of the one for the other might, and probably would, require the exercise of more or less mechanical skill, or what we prefer to call designing skill, or skill of adaptation, which is a higher order of ability than mere mechanical aptitude.

Having, by such a comparison as has been suggested, ascertained just what and where the differences in weight are, it would then be in order to test the strength of the lighter parts, and see whether it is equal to that of the heavier ones, and adequate to perform the work required of it. A still further inquiry could be made whether, by a different design and distribution of material or the use of a different kind or other method of manufacture, the weight of the part could not be still further reduced. Experience, of course, is the most reliable teacher; but, as has been remarked, "its lessons often come high." It would seem though, considering how conclusive its tuition is, that we all—but especially railroad companies—should give more heed to it. Daily and hourly it goes on inculcating its lessons on railroads, but those who might profit most by it are often blind and deaf to its instruction. It has often been observed that a scrap heap is a most instructive object of study. It shows what and where, and to some extent how breakage and failure occur; but in this, as in many other things, hasty inference is apt to mislead. What is needed is systematic records, such as have been kept by some of the heads of the mechanical departments of Western railroads, with drawings showing exactly what and how the parts of cars and locomotives have failed, and the number of failures. Such a record would suggest inquiries into causes, means of prevention, and show what should be avoided or modified. Having collected this information, its use and application, to get the fullest benefit from it, would require a very high order of ability in the adaptation of the design of parts to produce the best results. This latter is perhaps the most important capability which the investigator should have. In his preliminary investigations he should have a mental avidity for new information, which would eagerly accept and follow any clew which would be likely to throw new light on the subject, and also have that judicial turn of mind which would apprehend all the evidence and at the same time hold his judgment in suspense until the testimony was all taken, and then form his judgment of the case on the evidence gathered. The value of this character of mind in relation to other matters is of course recognized, but it seems doubtful whether those who are in supreme control of our railroads realize its value, or even recognize the possibility of

its existence in connection with purely mechanical matters. In fact, the impression is not unusual that a person to be a mechanical genius must be deficient in common sense in some if not most other directions. Invention itself, in its ultimate analysis, is a logical process, and the result of a quick apprehension of mechanical means and resources and more or less acute reasoning thereon. Sometimes the conclusions and inferences come quick as thought, at others they are evolved only after long and laborious investigation and contemplation.

The particular lesson which we want to inculcate here is that in such an investigation as has been outlined, and to effect a reduction in the dead weight of rolling stock, a very similar kind of ability is needed that would be required in any other scientific research, or, in fact, in almost any other enterprise or activity. But in any direction success only comes to those who have mental acuteness, sound judgment, long experience, and familiarity with the relations of the things on which they are engaged, and are capable of making new adaptations and modifications when these are demanded. Such capacity is required of an able lawyer, a successful business man, a great artist, author, or general, and, in fact, of any one who conducts successfully any department of human enterprise. If the services of one or more persons with the requisite mechanical knowledge and experience could be engaged in the task of diminishing the dead weight of cars and other rolling stock on our railroads, it seems certain that much could be accomplished in that direction, and that very large economy would be possible.

That there is great indifference with reference to the weight of cars also appears in various ways. It is doubtful whether one master car-builder or railroad manager in fifty could tell or has ever inquired how much the vestibule appliances now so much in vogue on passenger cars weighs. After some considerable experience in the construction of car-seats, we never knew but one railroad man who inquired about their weight, and it is generally very difficult to get accurate or correct information about the total weight of cars. It seems exceedingly probable that such an investigation as has here been outlined might reveal a condition of things the existence of which was not suspected by those who have long been living and working alongside of it.

NEW PUBLICATIONS.

"ENGINEERING NEWS." Our contemporary announces that Mr. William Kent has been appointed a member of the editorial staff of that paper, to take the place, it is presumed, of the late A. W. Wellington. On such occasions it is the duty of the veterans of the press to lift our hands and bestow a patriarchal blessing and invocation for success, which in this instance is a duty which it is also a pleasure to perform.

THE WILLIS PLANIMETRE. By Edward J. Willis, M.E., Richmond, Va. This instrument is illustrated, but very inadequately described in this little pamphlet of eight pages. The engravings originally appeared in the *American Machinist.* On the title-page it is said that it "reads areas in various units; also mean effective pressure and H.P. direct from indicator cards without calculation." The usefulness of this brochure would have been greatly increased if a clear and full description of the instrument and its operation had been given.

EVOLUTION OF THE AIR-BRAKE. *A Brief but Comprehensive History of the Development of the Modern Railroad Brake, from the Earliest Conception Contained in the Simple Lever up to and Including the most Approved Forms of the Present Day.* By Paul Synnestvedt. New York: *Locomotive Engineering,* 256 Broadway. 112 pp., $5\frac{1}{4} \times 7\frac{3}{4}$ in., $1.00.

This little book is the result of a revision and consolidation of a series of articles which originally appeared in *Railway Engineering and Mechanics.* Its sub-title, however, is misleading; it is not in any sense a "*comprehensive history* of the modern railroad brake." A correct title would be "*Scraps of Information* about the Development of the Modern Railroad Brake." In suggesting this title we do not mean to undervalue "scraps;" all we insist on is that the collection before us is not in any sense a "comprehensive history."

The general scope of the book will be indicated by the titles to the chapters. These are: Introductory; Power Brakes in General; Compressed-Air Brake; Hose Coupling; Air Pump; Governor; Engineers' Valve; Equalizing Discharge Valve; Triple Valve; Quick-Action Brakes; Wenger Brake; Quick-Action Brakes (Continued).

With such a field before him, the author had an excellent chance of making an admirable book by giving a lucid description of the way in which modern railroad brakes have been developed from their early beginnings. The subject, it must be admitted, is not an easy one to elucidate. Early forms of brakes are now, to a very considerable extent, involved in the obscurity with which time so quickly covers what has become obsolete, and the principles of modern power brakes are very difficult to understand and still more difficult to explain, and their construction is very complicated and also difficult of explanation and comprehension. To make a satisfactory book on such a subject, a very great capacity for clear exposition is needed. By no stretch of charity or good nature could this capacity be claimed for the author of the book before us. His description of steam, buffer, chain, hydraulic, vacuum and air brakes in Chapters 2 and 3 would be simply incomprehensible to even intelligent persons who have no knowledge of their principles or construction. The descriptions are inadequate and the explanations not understandable excepting to those who are already acquainted with the subjects. Then, too, some of the engravings are very bad. Take those on pages 18 and 19. They are simply execrable, and incapable of being comprehended. Others are nearly as bad, but they improve as the book advances, those in the latter half being tolerably good. The matter, as has been stated, consists of scraps of information taken apparently chiefly from patent specifications and trade catalogues, and giving illustrations of the various devices and organs of brakes which have been used from time to time, but with nothing approaching to a lucid explanation or description of the construction or operation of the parts illustrated. It is true that a miscellaneous lot of material cannot be collected together, even in a heterogeneous form, without having some interest and value, but in the present instance this value cannot be estimated very high.

THE REPORT OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Some sort of recognition is due to the commendable promptness with which the Secretary of this Association has brought out the Annual Report. The precise date of its appearance on the editorial desk we omitted to note, but if our memorate chronology is not at fault, it arrived some time during the month of July. It appears, too, with a somewhat gay and festively designed cover printed in colors, which betokens prosperity. The typography is excellent, although it is to be feared that remote posterity will not be able to make much use of the volume, owing to the quantity of wood in the paper. Our successors may, however, have little interest in locomotives of the kind which are discussed in this report, and in which some of us take so much pride.

The volume has 331 pages, and the Secretary reports a total of 600 members. A year before there were 587, so that there is a healthy growth. He also reports that Mr. George P. Hodgman, one of the Association's scholars, has graduated with honors at the Stevens Institute of Technology, which is a reminder of the fact that some of us are growing old and may soon be superannuated.

AMERICAN STEAM VESSELS. By Samuel Ward Stanton. New York: Smith & Stanton. 500 pp., $8 \times 11\frac{1}{2}$ in., $5.00.

The purpose of the author in compiling this volume, he tells us in his preface, "was to bring together in compact form for the first time correct illustrations and descriptions of all of the various types of American steam vessels from the beginning of their successful construction up to the present day." In the accomplishment of this object he has made a series of pen-and-ink drawings. "These," he says, "have been drawn from reliable sources—from early prints, lithographs, drawings and paintings, mostly in the possession of private parties or steamboat companies; and those of later days from photographs, plans, sketches, etc." From such material the author has made a series of pen-and-ink drawings which were exhibited at the World's Columbian Exposition, in Chicago, in 1893. These drawings are of a very sketchy, scratchy character, and their artistic excellence is not of a very high order. In such illustrations this is not a matter of paramount importance; the essential thing is historical accuracy. The statements made by the author in his preface leave the readers in a state of uncertainty with reference to the illustrations—that is, they cannot know how much of them is historical and how much is

the product of the artist author's imagination. If he was aiming to produce an authentic historical book, that purpose would have been accomplished better if he had reproduced the most authentic illustrations obtainable with the greatest fidelity possible; and if he had then given the fullest and most authentic data and information about the different boats and vessels illustrated, his book would have been a very valuable contribution to engineering knowledge. As it is, the book has not a high order of artistic merit, and its historical value is not nearly so great as it might have been made. All that can be said of it is that it is an interesting collection of picturesque illustrations, which give a general idea of the appearance and construction of early and latter steam vessels built in this country, and of the evolution of this branch of engineering The engravings are printed in blue or purple ink—for what object is not apparent. This color also detracts from the seriousness of the publication. Each vessel is represented by a full-page engraving—generally a side view; and on the opposite page the descriptive matter is printed, which has been inscribed with a pen in more or less ornamental characters, with an accompanying vignette representing a different view of the vessel shown by the full-page engraving and surrounded with very picturesque and ornamental borders printed in a different color from the prevailing purple of the engravings. Each one of these descriptions and the surrounding borders are of different design, and the latter are very picturesque and ornamental and represent some nautical object, as a rope, a fish, a wreck, a lighthouse, etc., in infinite variety. Some of the descriptions are, however, very difficult to read. Take as an example that referring to the steamer *City of Cleveland*, opposite page 260; it requires the strongest kind of eyesight to decipher it, and even with a magnifying-glass it is not easy to make it out. Now, the prime purpose of print is to be read, and no amount of decorative effect in lettering compensates for obscurity in letter-press. Most readers, it is thought, will agree in thinking that the most artistic features in the book are the marginal designs, which are, or should be, totally subordinate to its main purpose.

Beginning with Fulton's *Clermont* and ending with the American transatlantic passenger steamship *New York*, in all 249 vessels are illustrated and described. The book, therefore, is the most complete compendium of the history, progress and development of steam navigation in this country in existence. To a very great extent this history is given in the form of object lessons; and any one with the slightest interest in the subject will soon find himself fascinated with the pictures—those on the one page representing the results of prosaic engineering art, which in this somewhat vague historic record assumes an atmosphere of romance, and on the opposite page we enjoy the coruscations of the artist's fancy in the marginal illuminations. The book is well printed and bound, and, notwithstanding the deficiencies, is extremely fascinating and instructive; and there is no source from which an inquirer can obtain so much information about the evolution of steam navigation in this country, and could get it in such an agreeable way, as he can by going over the pages of this book.

BOOKS RECEIVED.

TRANSACTIONS OF THE ASSOCIATION OF CIVIL ENGINEERS OF CORNELL UNIVERSITY. Ithaca, N. Y. 128 pp., 6¼ × 9¼ in.

PROCEEDINGS OF THE UNITED STATES NAVAL INSTITUTE. Vol. XXI, No. 2. Edited by J. H. Glennon, Annapolis, Md. 438 pp., 5¾ ×9¼ in.

REPORT OF THE CANAL COMMISSION OF PHILADELPHIA, as Transmitted to the Select and Common Councils of the City of Philadelphia. 54 pp., 5¾ ×9 in. and map.

REPORT OF THE TWENTY-EIGHTH ANNUAL CONVENTION OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION. Edited by Angus Sinclair, Secretary. New York. 331 pp., 6 × 9 in.

CLASSIFICATION OF OPERATING EXPENSES, as Prescribed by the Interstate Commerce Commission. Revised issue, taking effect July 1, 1894. 28 pp., 5¼ × 8¾ in. Washington: Government Printing Office.

DECISIONS UPON QUESTIONS RAISED UNDER THE CLASSIFICATION OF OPERATING EXPENSES, as Prescribed by the Interstate Commerce Commission. Bulletin No. 1. 9 pp., 5¼ × 8¼ in. Washington: Government Printing Office.

REPORT ON THE USE OF METAL RAILROAD TIES, and on the Preservative Processes and Metal Tie Plates for Wooden Ties. By E. E. Russell Trabman. (Supplementary to Report on the Substitution of Metal for Wood in Railroad Ties, 1890.) Prepared under the direction of B. E. Fernow, Chief of Division of Forestry. 363 pp., 5¾ × 9 in. Washington: Government Printing Office.

TRADE CATALOGUES.

IN 1894 the Master Car-Builders' Association, for convenience in the filing and preservation of pamphlets, catalogues, specifications, etc., adopted a number of standard sizes. The advantages of conforming to these sizes have been recognized, not only by railroad men, but outside of railroad circles, and many engineers make a practice of immediately consigning to the waste-basket all catalogues that do not come within a very narrow margin of these standard sizes. They are given here in order that the size of the publications of this kind, which are noticed under this head, may be compared with the standards, and it may be known whether they conform thereto.

IT seems very desirable that all trade catalogues published should conform to the standard sizes adopted by the Master Car-Builders' Association, and therefore in noticing catalogues hereafter it will be stated in brackets whether they are or are not of one of the standard sizes.

STANDARDS.

For postal-card circulars	3½ in. × 6¼ in.
Pamphlets and trade catalogues	3½ in. × 6 in. 6 in. × 9 in. 9 in. × 12 in.
Specifications and letter-paper	8½ in. × 10½ in.

CATALOGUE OF SPRINGS FOR STREET RAILWAYS. Charles Scott Spring Company, Philadelphia. 13 pp., 6 × 9 in. [Standard size.]

We have here illustrated with excellent wood engravings various kinds of elliptic, helical and spiral springs used under and in connection with the lighter class of cars. The company also makes light extension springs for trolley stands, brush holders, and also car window sash springs, all of which are illustrated in the catalogue before us.

AN IDEAL ENGINE ROOM. Harrisburg Foundry and Machine Works, Harrisburg, Pa. 3½ × 6¼ in. [Standard size.]

Boston has a new theatre called Keith's, the electric lighting plant for which is supplied with three "Ideal" engines built by the above company, which have 15¼ × 14-in. cylinders, are rated at 175 H.P. each, or an aggregate of 525 H.P. The theatre is said to be in every way admirable, including the engine-room, which has recently been described in some of the Boston papers, which say that it is in every way the finest and most complete in the world. According to these authorities, it is finished in marble, frescoes, and is lighted like fairyland. There are dados, stuccos, easy-chairs, etc., and from all this scene blue overalls and "jumpers" have been banished, and the engineers, "handsome of feature and strong of build, flit here and there in the performance of their duties in white duck trousers and cheviot suits." These descriptions the Harrisburg Company have reprinted in a convenient form, and have not forgotten to illustrate the different types of their engines with excellent little half-tone engravings in the back part.

THE STERLING EMERY WHEEL MANUFACTURING COMPANY, TIFFIN, O.

Like everything else, the manufacture of emery wheels in these modern progressive times has been undergoing a process of evolution. The processes and appliances of manufacture have been systematized, and, like the traditional pork butchery in the West, when the pigs are driven in at one end and are "passed" out at the other end in the form of sausages, so at the progressive works named at the head of this article, the crude emery stone is brought in and elevated into bins containing the various grades, from which it is carried through conveyers to the places where it is mixed. It is then moulded into wheels, which must then be carefully dried. They are then turned to the proper size and again dried, after which they are subjected to a baking process which occupies four or five days. They are then trued up and tested by running them at double the speed at which it is intended they shall be used. They then become a commercial article. Corundum wheels, to be run wet or dry, are a specialty of this company, and are now used for a great variety of purposes.

Besides the manufacture of emery wheels, this company also makes the grinding and polishing machinery on which their wheels are used. A variety of machines are now included in their list.

THE USE AND CARE OF BAND RE-SAWS. W. B. Mershon & Co., Lumber Manufacturers, Saginaw, Mich. 40 pp., 5¼ × 7¾ in. [Not standard size.]

The publishers of this pamphlet, by way of introduction of themselves, say: "We handle about 40,000,000 ft. of lumber annually. Over 90 per cent. of it is dressed or manufactured in our planing and door and box factories. A great deal has to be re-sawed. After years of experience in using the different standard makes of re saws, both circular, solid, and segment and band, and profiting by the experience thus obtained,

our Mr. E. C. Mershon decided to construct a re-saw which would be free from the imperfections which had come to his notice. To do this, it was necessary to make new designs throughout, and to construct a machine new in every respect from beginning to end."

In the catalogue which this firm has issued this re-saw is illustrated and described. The illustrations are passably good half-tone engravings in which several different views of the machine are shown. This is followed by directions for the care of the machines and their saws, especially the latter. Diagrams and directions are given for hammering, straightening, filing, hanging, and brazing saw blades. These are followed by illustrations and descriptions of a combined band re-saw and rip-saw, of which several views are given. The book, which is well printed and papered, ends with a series of testimonials giving evidence of the merits of these machines.

BORING AND TURNING MILLS. The Bullard Machine Tool Company, Bridgeport, Conn. 32 pp., 6¾ × 10 in. [Not standard size.]

This catalogue is an example of Bartlett & Company's excellent work—or perhaps it ought to be called high art. The illustrations consist of half-tone engravings representing outside and inside views of the company's factories at Bridgeport. These are succeeded by views of a 37 in. boring and turning mill with one head, a view of a similar machine with two heads; 51-in., 60-in., and two 62-in. machines with two heads; a 30-in. boring and turning mill with turret head; a 24 in. lathe; a turret machine suitable for studs and bolts from ½ in. to 2½ in., and finally a 32-in. combination turret machine. These illustrations are all half-tone engravings, apparently made from photographs which have been touched up to bring out their obscurities. This has not been done, however, in that offensive way which is characteristic of some work of this kind, and which has the appearance of violent striping of the object touched up; but all that has been done is merely to develop what without such treatment would be obscure. The engravings are printed with a fine black line around the edge, and outside of this is a delicate gray tint about ½ in. wide, which is produced by a separate printing. The effect is admirable, especially as the engravings and text are both printed on heavy coated paper, the typography and the binding all being in excellent taste. The cover is of heavy gray rough paper, the binding being effected by a purple string by which the sheets and cover are held together. Short descriptions of the different machines are printed opposite to each engraving.

CONDENSING AND NON-CONDENSING ENGINES APPLIED TO ROLLING MILLS. 13 pp., 6 × 9 in.

RULES AND TABLES FOR THE EQUALIZATION OF POWER DEVELOPED IN THE CYLINDERS OF COMPOUND ENGINES. 8 pp., 6 × 9 in.

LIST OF STANDARD FLY WHEELS. Philadelphia Engineering Works, Philadelphia. 8 pp., 6 × 9 in. [Standard size.]

The first one of these papers, as its title indicates, contains a presentation of the arguments for the use of compound locomotives in rolling-mills. It is illustrated first by a perspective view of one of the Philadelphia Works tandem compound engines; second, a series of ideal indicator diagrams showing the action of steam in the cylinders of such an engine; third, an outline engraving representing a side view of a similar engine; and lastly, a half-tone engraving of an engine designed on the proportions recommended by this company.

The character and scope of the second pamphlet is sufficiently explained by its title.

The third one describes the "built" fly-wheels made by this company. In these the rim spokes and hub are made in separated pieces and bolted together in a very ingenious and, it would seem from the illustrations and descriptions, a very secure way. An excellent wood-engraving showing a perspective view of such a wheel is shown in the front page, which is succeeded by descriptions of the merits and methods of manufacturers of these wheels. This is followed by tables giving sizes, weights, capacity, etc., of the different wheels made by the company. The last page has rather a poor half-tone engraving showing a double-built wheel being turned in a lathe. These publications are neatly printed, "papered," and bound, and have a general business-like appearance and character.

COMPRESSED AIR AND THE CLAYTON AIR COMPRESSORS. Complete Catalogue No. 8. Clayton Air Compressor Works, Havemeyer Building, New York. 86 pp. 8½ × 10¾ in. [Not standard size.]

The uses of compressed air are extending so rapidly, and it is now applied to so many purposes, that any literature on the subject is welcome. The Clayton Company in the publication before us, have republished an article on the Widening Uses of Compressed Air, which originally appeared in the *Engineering Magazine*. They then describe and illustrate the various kinds of air compressors which they make, and from the illustrations and descriptions which are given it will be seen how this branch of engineering has been developed. A somewhat fuller description of the principles and construction of air compressors would, it is thought, have added to the usefulness of this catalogue, but what there is is good. Various forms of governors are described and illustrated, which are followed by short articles on the Loss of Pressure due to Friction in Transferring Air through Pipes; Capacity Lost by Air Compressors, and Suggestions to Correspondents when Writing for Quotations. A large number of illustrations, which represent duplex and single steam-actuated compressors, with tabular statement of dimensions and capacity of different sizes. Similar illustrations and data are given of duplex and single-belt-driven compressors of various kinds. A great variety of forms and sizes, including vacuum pumps, are described, which are used for various purposes. Following these, directions for erecting and operating the compressors and suggestions for ordering duplicate parts. Various kinds of air receivers, steam boilers, the Monarch rock drill, and steam pumps are also made by this company. The volume ends with several pages of testimonials relating to the merits of the Clayton machinery.

LIGHT CARS, SHEFFIELD CAR COMPANY, Three Rivers, Mich. Special Foreign Edition, printed in English, French, German, and Spanish. 40 pp., 6 × 9 in. [Standard size.]

The Sheffield Company, as most of our readers know, manufacture light cars, or what are generally classed as hand cars. One of the principal types of this class are what are called velocipede cars, which are very fully illustrated by excellent half-tone cuts made from wash drawings. The only fault which we are disposed to find with these illustrations is that the occupants of the cars are not, or at least do not look like, working men. Their appearance indicates that they are dressed for some social "function" and not for doing or supervising track repairs. A word of commendation is due to their barber, as their whiskers and mustachios are all faultless.

It is always safe to assume that in writing on any subject there will always be some readers of what is written who will be absolutely ignorant of the subject of the article. To such it will be said that the velocipede which the Sheffield Company makes has three wheels, two of which run on one rail, tandem fashion, and support the person or persons riding on it. A long arm or lever extends at right angles across the track to the opposite rail and carries a small third wheel, the use of which is simply to steady the vehicle and keep the two carrying wheels in the proper relation to the rails on which they run. The vehicle is propelled by means of a vertical oscillating lever connected by cranks and suitable gearing to the driving-wheels.

The author of this catalogue has evidently made the same assumption which we have, and has assumed that his foreign readers are ignorant of the uses to which these cars are put in this country. He has, therefore, written an excellent introductory article describing exactly how repairs are made on American lines, and the rolling stock which they are provided with, and the uses that are made of it.

Succeeding the illustrations of the velocipede cars, some rather peculiar illustrations are given of section hand cars. These have four wheels, and are propelled by horizontal oscillating levers and gearing. The levers are worked somewhat as a pump handle is. The cars were apparently painted a light color, and are taken with a dark background. They therefore have a sort of weird or ghostly appearance which is not altogether pleasing.

An excellent wood-engraving of a push car, stand pipe, and car wheels are also given, with descriptions of each. The light all-steel wheels which this company make have some peculiarities, but would take too much space to describe. A rather sensational picture of a tunnel car and an excellent view of their works completes the volume, which is in every way commendable.

TRIALS OF OIL ENGINES.

Two trials of oil engines have been made in Europe that are of considerable interest in that they have a direct bearing upon the substitution of that type of motor for the steam engine in agricultural work. One was made in Berlin by the German Agricultural Society, and the other at Meaux, France, by the Agricultural Society of that place. The full report of the former, of which we publish an abstract, appeared in the

Arbeiten der Deutschen Landwirthschafts Gesellschaft, and of the latter in the *Bulletin du Syndicat Agricole de Meaux* :

At the German trial only engines working with an inflammable mixture of petroleum gas and air were admitted to the competition. Each engine was tested as follows :

1. With a brake (*a*) at full power for one hour ; (*b*) at half power for one hour ; (*c*) running empty for half an hour, and about five minutes at the maximum possible power. Indicator diagrams were taken at the same time. During these trials the consumption of petroleum, of lubricating oil, and of cooling water : temperature of the water in and out ; efficiency ; steadiness in running ; variations of speed ; and maximum power developed were determined.

2. While driving one or more agricultural machines with rope transmission, when the following points were studied : Simplicity ; time required to start ; automatic regulation of the speed ; accumulation of dirt after running for 60 hours ; smoothness in working ; time and labor required to clean the engine ; noise, smell, inconvenience from the exhaust ; and weight of the portable engines with special reference to the cooling water used.

In awarding the prizes, the economy of the engine was calculated as regards consumption of petroleum, of lubricating oil and water ; also interest upon capital and cost of repairs ; the motor being supposed to run 1,000 hours in the year.

The oil was supplied by the society. American petroleum of 0.80 and Russian petroleum of 0.82 density were used indiscriminately for all the engines.

Since gas motors are out of the question in the country, the development of portable oil engines is a subject of much importance for agricultural proprietors. They obviate many of the difficulties connected with steam engines and boilers, such as weight, transport, inconvenience of carrying water and combustible, danger of fire and constant supervision. These competitive trials were specially designed to test the deficiencies of this class of engine ; and it was hoped that a thoroughly serviceable and efficient agricultural oil motor might be the result. Unfortunately many makers who had hitherto given little attention to the subject were induced, in order to take part in the competition, to construct engines too hastily. Badly designed motors were the natural result ; and the same may, in the author's opinion, be said of the English engines tested at Cambridge in 1894. In the course of the next few years these difficulties will certainly be overcome. The trials at Berlin showed, not the perfections of portable oil motors, but the defects to be remedied.

Twenty-seven engines were exhibited—viz., six portable and five stationary engines from 8 H.P. to 12 H.P. ; six portable and 10 stationary engines from 2 H.P. to 4 H.P. ; some were afterward withdrawn. No maker was allowed to have more than two engines tested. Fifteen firms competed—all German except that of Robey. Drawings with detailed description of all the motors are given in the original paper. The author emphasizes the fact that the engines, both portable and stationary, were tested solely for their suitability for agricultural purposes.

All were four-cycle engines ; they varied chiefly in their method of vaporizing the oil, valve gear, ignition and regulation of the speed. The vaporization or gasification of the petroleum may take place in different ways. Sometimes it is sprayed into a red hot space, called the vaporizer, and converted into vapor by the heat, the piston then drawing it into the cylinder, together with a proper quantity of air. Sometimes the petroleum is broken up by a blast of air, and injected into a hot chamber, a certain amount of heat being necessary to prevent the recondensation of the oil vapor. Some makers use all or part of the gases of combustion to heat the vaporizer. The oil is sometimes vaporized in a separate space, sometimes an air chamber is used. Although the vaporizer must always be heated, it need not be kept red hot unless it also serves to ignite the charge. If the heat is not supplied by the gases of combustion, a lamp is used ; or, the vaporizer being open to the cylinder, the heat of the explosions is sufficient to maintain it at a proper temperature. A lamp must always be used at starting. The vaporizer is the most important part of the engine, because if the oil is imperfectly vaporized the consumption is increased, and dirt accumulates in the engine. The sprayer is usually a kind of nozzle with fine holes through which the oil is injected into the stream of air. The valve gear is about the same as in gas engines. Ignition is generally with a hot tube heated by a lamp. There is no timing valve, the tube being open to the cylinder ; but the gases do not ignite until the end of the compression stroke. In some engines the vaporizer is kept red hot and ignites the charge. Very little air must in this case be used to spray the oil, for if the mixture in the vaporizer were inflammable premature ignition would take place. Until the moment of ignition, therefore, the charge should contain too little air to burn, and air for combustion must be separately admitted and forced by the compression stroke into the vaporizer. This arrangement, introduced by Grob, is also used in the Daimler.

In reviewing the portable engines the author remarks that nearly all were ordinary stationary motors mounted on wheels, with the addition of a condenser, an oil and sometimes a water-tank. The judges considered that the aim should be to produce motors complete in themselves, with as little vibration as possible. A decided preference was given to those with horizontal cylinders. With vertical cylinders, the parts of the motor vibrate perpendicularly ; and in a portable engine this action, especially on bad soil, causes the wheels to sink into the ground. During the trials the Seck 4-H.P. stationary motor consumed 0.96 lb. of petroleum per B.H.P. hour ; in the portable engine of the same type the consumption increased to 1.48 lbs. per B.H.P. hour, and the vibrations were very marked. After the engine had been more firmly fixed the consumption fell to 1 lb.

The trials began by an inspection of all the engines at work, that the smell might be noted. They were then started cold, and observations were made of the time required before they were in full working order, the difficulty of starting, and whether a lamp was sufficient to heat them without the addition of a fan. A Prony brake, an indicator, a counter and tachometre were then added. It is of importance to determine the variations in the speed in oil motors, as they are chiefly governed by cutting out ignitions. In most agricultural engines, even at full power, from 10 to 20 per cent. of the ignitions are missed on account of the variable nature of the work. During these trials, therefore, the ignitions per minute were counted. Each maker supplied his own lubricating oil. The consumption of petroleum was carefully noted, but it was not always possible to measure the quantity of cylinder cooling water.

The engines were worked at the different powers without stopping to test their smooth and regular running. Note was also taken of their cleanliness. When the oil was not perfectly burned, the result was not only a larger consumption, but need for frequent cleaning. A point of importance was whether this cleaning could be carried out by an ordinary laborer ; but with most of the engines this was not the case. The protection of the different lamps from sudden extinction, particularly when burning in the open air, was also observed, and specially the arrangements for cooling the circulating water. This water on leaving the cylinder jacket is usually cooled by a current of air from a fan, and it is essential that the fan be driven with regularity, and the pulley and strap not allowed to get wet. In many of the motors it was found impossible to work continuously because the fan strap slipped or came off, and the water was insufficiently cooled. Other difficulties in this respect were also experienced.

After the brake trials, the engines, both stationary and portable, were tested while driving threshing machines ; in this work some of them broke down. The best were then selected for a final trial of 60 consecutive hours. These were the Deutz, Hille, Schwartzkopff, Seck, Dürkopp, Langensiepen and Körting.

This trial was purposely made as arduous, and the power as intermittent, and as much like agricultural work as possible. The working efficiency was tested under varying loads, two different oils (Russian and American), and other conditions subject to change during work in the fields. The engines were watched night and day, and the amount of attention they required was noted. The power developed was used to generate electric light and to drive threshing and sawing machines. Although all the motors ran through this trial, some with difficulty, the judges considered that none were worthy of a first prize. With some, when in full work, the water was not properly cooled, the cylinders became too hot, and a violent shock was produced at each explosion. In others the lamp went out ; and with all, especially the portable, much vibration was observed, due principally to insufficient cooling of the circulating water. The stationary engines, being connected to a water main did not vibrate so much. The farmers complained most of the difficulty of varying the power in the portable motors.

After the trial they were cleaned in the presence of the judges. The small Deutz and Körting were found less dirty than the others, and took only from 25 to 40 minutes to clean. The larger engines required from 40 to 70 minutes, and two or three men were usually employed. Most of them were found in very good condition.

As the heat efficiency could not be determined without knowing the heat value of the combustible, two samples, one of American, one of Russian petroleum, were sent to the chemical station to be tested for heating value and chemical composition, with the following results :

American petroleum—constituents C 84.54 per cent.; H 14.06 per cent.; O 1.38 per cent.
Russian petroleum—constituents, C 85.52 per cent.; H 13.98 per cent.; O 0.50 per cent.

American petroleum—heating value per lb., 19,380 T. U.; specific gravity at 15° C., 0.797 ; flashing-point (Abel), 25° C.
Russian petroleum—heating value per lb., 19,580 T. U.; specific gravity at 15° C., 0.825 ; flashing-point (Abel), 31.5° C.

The results of the trials at the four powers developed, including time required for heating up, number of ignitions missed, and piston speed, are given in the original paper. The weight, price, and size of each engine are also added.

The consumption of petroleum, as shown in the table, varied greatly, the lowest being in the Altmann, 0.83 lb. per B.H.P. hour ; the mean consumption of larger power was about 1 lb. per B.H.P. hour. The number of ignitions missed show how much the power can be increased ; in agriculture, where the amount of work varies greatly, this is of special importance. The author also calculates the actual power exerted per unit of piston surface and unit of time—in other words, the absolute, or what he calls the specific efficiency of the engine. Although the judges did not intend to base their awards upon this specific efficiency, it was found that the engines developing the highest absolute power were always the best in other respects.

When they were run at half instead of full power, the consumption of oil and number of explosions missed increased considerably. In agricultural work the mean power should be between these two. For instance, the 88 H.P. Altmann ought normally to develop 6 H.P., and its consumption would then be about 1.1 lb. oil per H.P. hour. As the consumption of petroleum is relatively very high when the engines are running empty, it is not advisable that they should do so for long. On the other hand, starting, especially for larger powers, is often troublesome. The times required for starting, and the cleaning after a short run, are given in the original paper.

The indicator diagram is the best guide for studying the cycle of work in a cylinder, especially if a brake experiment be made at the same time. The soot collecting inside the indicator, especially in oil engines, may, however, affect the friction, or an error arise in counting the number of ignitions missed, when not counted continuously. The author selects one diagram as an example to explain a method adopted by him to calculate the working, with reference to the distribution of heat. It is mentioned in his paper on "A Dynamic Theory of Steam Engines," in the *Zeitschrift des Vereines deutscher Ingenieure* (1892, p. 1). He considers the indicator diagram valuable chiefly to show how work is produced and how expended. In the usual method of calculating it the total indicated work is shown, but no count is taken of the fact that this is only a fraction of the total work produced by the combustion of the petroleum, and converted into pressure on the piston. In studying an oil engine it is important to know what becomes of the work, and therefore the indicator diagram must be divided into parts representing so many fractions of work done. The contents of these areas are calculated by the author in a special way, and he shows the amount of work done during admission, compression, expansion and exhaust, by means of vertical ordinates. Account must always be taken of the pressure of the atmosphere on the outer face of the piston. The actual work done will be the difference between the work of admission, compression, expansion, and exhaust, and that of driving back the air. The latter should be subtracted from the work of expansion to give the true indicated work.

The influence of the compression space is considerable in all four-cycle engines. The author shows the proportion between it and the total cylinder volume in all the motors. Thus in the Deutz the compression was nearly half the total volume. During explosion the pressure rose from 7½ to nearly 20 atmospheres. If there were no compression space, the whole of this rise in pressure would be immediately converted into useful work on the piston ; with the present methods of construction the greater part is wasted. This pressure generated in the compression space being, like the other values, translated into work and represented by an ordinate, the author proves that it is equal to about three times as much as the indicated work shown in the diagram. If to it be added the energy of the gases discharged, it will be seen that the work wasted is far greater than the work done. The diagram of this pressure, which is shown as the clearance space at one end of every indicator diagram, ought really to be added to it in estimating the work done by the heat given to an engine.

The author classifies the work as follows :

1. Total work, or that shown in all the diagrams combined.
2. Work of explosion, or difference between the absolute and compression work.
3. Work of expansion.
4. Work lost in compression space.
5. Indicated work.
6. Work done on the brake.
7. Work of compression.
8. Work of driving out the air.
9. Work of friction.

All these are represented graphically by curves in the original paper, and the author estimates that only about one quarter of the total work is shown on the brake, the rest being absorbed in friction, compression, and the cycle of work. The mean pressures exerted during these different kinds of work, the friction pressure per unit of piston surface, and the maximum pressure of expansion and compression, are all shown in tables, a study of which reveals how the heat developed has been expended and how much its utilization depends upon the dimensions of the engine, etc. It is not probable, however, that four cycle engines can be greatly improved in this respect, because a compression space is indispensable.

Another table gives the proportions in which, in the different engines, the nine kinds of work were distributed. Thus in the Altmann the total work was 70 per cent. of the total heat given. The heat utilization in this motor was therefore good, but unfortunately there was much vibration.

The author concludes with a comparison of steam, petroleum, and other heat agents. He is of opinion that a field is open for oil motors, which are the most convenient for agricultural purposes, and avoid the difficulties of steam and generator gas engines. They are not, however, so simple, and the motive power, explosive gas, has not the same properties as steam ; they need frequent cleaning and much care and attention, but they utilize the heat developed extremely well. In most of the engines there were parts too delicate to be handled by common laborers, although portable motors ought to be made to bear rough treatment, shaking and jolting over bad roads. Although the engines were in some respects defective, many with slight modifications would be suitable for field work. Time, patience, and attention to detail are needed to attain perfection, and few things can contribute more to this desirable result than careful and accurate tests.

At Meaux, eight engines were tested : two English (Hornsby-Akroyd and Griffin), both stationary ; three French (a Merlin portable engine and two Niel, one stationary and one portable) ; two German Grob motors, one stationary, one portable ; and one Swiss stationary, by the Société Suisse de Winterthur. The following table gives the principal dimensions and results :

CONDENSED TABLE OF OIL-ENGINE TRIALS.

Name of Engine.	Diameter of Cylinder.	Stroke.	Revolutions per Minute.	Consumption of Russian Oil per B.H.P. Hour.	Brake H.P. Maximum.	Thermal Efficiency.	Cylinder Cooling Water per Hour.
	In.	In.		Lbs.		Per Cent.	Lbs.
Grob (stationary).........	7⅞	7⅞	311	0.59	7.8	21.2 max.	483
Niel "	7½	14½	183	0.67	6.2	18.7	341
Merlin (portable)..........	6 7/16	6 7/16	283	0.76	4.8	16.6	145
Winterthur (stationary) ...	6 3/16	9⅞	226	0.84	5.2	14.9	133
Grob (portable).	7⅞	7⅞	263	0.92	6.2	13.7	2,557
Griffin (stationary)... ...	6	12	218	0.93	7.4	13.6	330
Hornsby-Akroyd (stationary)........	8	14 1/16	205	1.0	5.7	10.4	649
Niel (portable)	7½	14½	177	1.54	6.4	8.2 min.	4,752

The author first draws attention to the fact that oil engines are much more generally used in Germany and England than in France and America, and very few new types are made in the two latter countries. At the Chicago Exhibition scarcely any American oil motors were shown. In France the heavy duty on petroleum has hitherto prevented its general use. Till 1893 the duty in Paris was equal to the value of the oil, and though it has since been reduced, petroleum is still six times dearer in Paris than in America.

All the engines were tested with the same Russian oil, supplied by the society. Its mean density was 0.823 flashing-point (Abel's test), 84° F. ; heating value in a Mahler calorimetre 19,872 T.U. per lb. ; chemical composition—C 84 per cent. ; H 15 per cent. ; O and N (by difference) 1 per cent.

Each engine was tested four times—viz., first running light, then at 2 B.H.P., at 4 B.H.P., and at maximum load. The experiments were in most cases continued for three or four hours, and the engine was run for about an hour before

beginning the trials. Each exhibitor was allowed as much oil as he required, and every precaution was taken to make the trials as complete as possible. The following data were noted: oil or spirit required for ignition and lubrication, consumption of petroleum, barometric pressure, temperature of the air, of the water in and out of the cooling jackets, and of the exhaust gases; quantity of cooling water, number of explosions and of revolutions per minute, and variations in the speed. Indicator diagrams were taken where possible. The B.H.P. was determined by a special automatic brake of thin sheet iron, fully described with drawings in the original paper. All the engines tested were single-cylinder, four-cycle and single-acting.

The petroleum was fed into the cylinders either by gravity from a reservoir above, by an oil pump, or injected with compressed air—a method followed in the Griffin engine, and which certainly contributed to its high thermal efficiency. The engines were started by hand, and all had cooling-water jackets. The cooling of the cylinders should be carefully regulated, for if too much heat is carried off the oil is not properly vaporized; if too little, dissociation and "cracking" may occur, with griping of the piston. The author is of opinion that the quantity of circulating water ought to be regulated by the number of explosions per minute—in other words, by the amount of heat generated in the cylinder. In the Grob and Niel engines the same quantity of water was sent by the pump to the jackets, whatever the power developed. Hence the cylinders in some cases were too much cooled, the loss of heat was great, and the consumption of petroleum excessive, the oil going to heat the cylinder walls instead of being turned into useful work. Thus the water cost too much, not only for the unnecessary work of the pump, but to keep the walls at the required temperature. The best engine in this respect was the portable Merlin, in which the water was sent into the jackets by a pump acting only at each explosion, and checked by the governor whenever the normal speed was exceeded.

Drawings with detailed description and a careful criticism of the engines are given in the original paper. As shown by the table, the consumption of the Niel portable engine was very large—more than double that of the stationary engine by the same maker—and the thermal efficiency proportionally small; this is attributed by the author to the large quantity of water circulating in the jacket. The different engines are then reviewed with reference to their thermal efficiency, quantity of heat carried off by the cooling water, heat balance, air used in each engine for the combustion of 1 lb. oil, variations in the speed, and consumption of petroleum. The results obtained under these heads are tabulated, and most of them are represented graphically.

The calorific value of the petroleum, the consumption per hour, and the work done being known, the thermal efficiency can be calculated. Heat is lost to the walls, to the exhaust, by radiation, absorbed by the lamp and by friction. To determine the thermal efficiency the B.H.P. developed was converted into calories and divided by the heat units in the petroleum, giving the proportion of heat turned into work to the total heat supplied to the engine. The best engine in this respect was the Grob stationary; but according to the author the efficiency of all the oil engines was much higher than in agricultural steam engines of the same power. The thermal efficiency is of great importance, for if it is high the engine, although faulty in other respects, can without difficulty be improved in detail.

To ascertain the air used for combustion it was necessary to know the number of explosions per hour, volume of the piston and consumption of oil, and from these the volume of air per pound of oil burned was calculated. The difference between this actual quantity and the theoretical helped to explain why some engines consumed more oil than others. Either the amount of air admitted was too large, and the charge in consequence not sufficiently inflammable, or the quantity was too small, and incomplete combustion and smoke were the result. The comparison of these figures with the thermal efficiency shows how much air ought in practice to be admitted into an engine cylinder per pound of oil.

A constant speed is most important, especially in engines intended to drive dynamos. The Griffin and Merlin engines were the best in this respect. The consumption of petroleum per hour increased in all the engines with the power, but not to the same extent; it was much affected by the temperature of the walls and the quantity of air admitted for combustion. The oil required for starting, when running empty, for the lamp, and per day, were also determined. The author tested these 4-H.P. engines during a working day of 10 hours, running one hour empty, two hours at 2 B.H.P., six hours at 4 B.H.P., and one hour at 5 B.H P.

A number of comparative experiments and scientific determinations were also made. Professor Witz has shown that the thermal efficiency increases with the speed of the engine, and that the combustion of explosive mixtures is the more rapid the greater the speed. Dr. Slaby has also demonstrated that the losses of heat to the walls unquestionably diminish with the increased speed. In an experimental engine they fell from 40 per cent. to 33 per cent., when the speed rose from 104 to 107 revolutions per minute. Under this head the author remarks that in engines giving the highest thermal efficiency when running at 4 B.H.P. this efficiency increased with the speed. Thus in the Grob stationary engine the thermal efficiency was 17 per cent. with 312 revolutions; in the Niel it was 15 per cent. with 184 revolutions. He considers that the thermal efficiency rises with the speed of the engine owing to the better utilization of the combustible and the smaller loss of heat to the walls. Hence the speed of a gas or oil engine is of much importance. If a small power single-cylinder oil motor runs, like a steam engine, at 100 to 120 revolutions per minute, it is costly, bulky, and the combustible is imperfectly utilized.

The author proceeds to classify the engines according to their cost of working, excellence of construction and running, and thermal efficiency. The comparative perfection of their construction was determined according to the balance of the different parts, capacity of the engine for running empty or at any power, regularity of speed, ease in starting, and time required to start. These were calculated according to different coefficients, and combined in a table with the thermal efficiency. The Grob stationary engine, although giving the greatest thermal efficiency, was not so good in other respects as the Merlin, and the portable Grob motor was the worst.

The main object of the experiments was to bring these interesting and practical oil motors before the public and make them better known, and the author hopes that the results published will help to advance the cause and improve the construction, their value for agricultural and other purposes being now generally recognized.

ROUNDHOUSE AT READING.

THE roundhouses, of which we give the reproduction of a photograph on the opposite page, were built by Mr. Milholland for the Philadelphia & Reading Railroad at Reading, Pa. At the present time the one nearest the observer is used as a paint shop, while the other is still reserved for the purpose for which it was built. The peculiarity that strikes one at first sight is the row of gable ends marking the location of each stall This arrangement is one that possesses some advantages over the usual smooth roof, in that the smoke from the stack is carried out more readily by the natural upward draft that prevails. These houses have been kept in excellent condition, and for all intents and purposes are as good as new. The roof is of slate, and the monitor is carried by phœnix columns. The plates are of cast iron, with sockets for the rafters cast on. The rafters themselves are of wood. The turn-table, which, of course, is in the centre of the building, has a cement floor. Above it and just inside the monitor there is a gangway held by sling stays dropping down from the dome trussing. The attractive feature internally is the light and airy appearance of the whole structure, whose roof seems to float rather than be carried on the slender columns beneath. This lightness is, undoubtedly, partially due to the excellent ventilation above the pits. The structure was completed in 1865.

DEFINITIONS WANTED.

A CORRESPONDENT writes: "Will you please define in your valuable journal what are to many people, quite justly, I think, the vague terms, 'fire surfaces, heating surfaces, and boiler surfaces?'

"In my opinion the *fire surface* is that portion of a boiler which comes in direct contact with the fire.

"The *heating surface* is that portion of the boiler which is actually against the coal or liquid fuel, while the *boiler surface* seems to me to have the broad meaning of every part of the boiler, whether in the fire or out of it."

It seems doubtful to us whether any of these terms excepting heating surface has any exact meaning assigned to it. Any portion of the internal or external surface of a boiler through which heat is transmitted from the fire to the water is generally regarded as heating surface, although Seaton, in his book on the "Marine Engine," says that. "strictly speaking, all surfaces exposed to heat which are capable of absorbing, and their bodies of transmitting, that heat to the water or steam are heating surfaces; but technically only certain parts are reckoned as *effective* heating surfaces, and the aggregate of

such surfaces is called the *total heating surface.* The surface of the upper half of the furnace, or the part above the level of the fire-bars, that of the combustion chamber above the level of the bridges, and the back plates, including the actual surface of the back-tube plates, are reckoned as the effective heating surface of furnaces and chambers, and are stated separately, chiefly on account of the metal forming them being three or four times the thickness of the tubes."

Robert Wilson, in his "Treatise on Boilers," says: "In estimating the extent of heating surface it is customary to take the whole area of furnace, combustion chamber, flues, water-tubes, etc., in contact with the heat on one side and the water and steam on the other."

Fire surface, so far as we know, has no exact meaning, although it seems as though it should mean that surface through which heat is transmited directly from the fire to the water, either by contact or radiation.

Boiler surface may mean either the external or internal or any other portion of its surface.

ROUNDHOUSE OF THE PHILADELPHIA & READING RAILROAD AT READING, PA., BUILT IN 1865.

THE JAPANESE NATIONAL INDUSTRIAL EXHIBITION IN KIOTO.

In 1877 it was promulgated by the imperial ordinance of Japan, that in order to encourage the development of agriculture, arts, and commerce, the national exhibitions should be held in different parts of the empire. The present exhibition, which was opened in Kioto on April 1, is the fourth, the other three being held in Tokio in the years 1877, 1881, and 1890. For the present exhibition Tokio and Osaka, which are the two largest cities, were rivals for the site of the fair, but the city of Kioto petitioned that the fourth exhibition should be held on the occasion of the eleven hundredth anniversary of the Emperor Kwammu's founding the city. Accordingly the petition met the approval of the government and a large majority of the members of the Imperial Diet.

Before describing the exhibition, it will be interesting to state briefly about the city of Kioto. Kioto is sometimes called Saikio, which means the western capital, while Kioto means simply a capital or *meaco* (or, more properly, *miyako*), as was printed in old maps. The name of Saikio came into use since the revolution of 1868, when Yedo was changed to Tokio, which signifies the eastern capital. In ancient times Kioto was known as Heianjo, or the "city of peace." The city is situated in latitude 35° 1′ 7″ north and longitude 135° 46′ 7″ east. It is 162 ft. above the sea-level, and is near the centre of the province of Yamashiro. Through the eastern part of the city the river Kamo flows. The river Kamo unites with the river Katsura in the village of Toba, a southern suburb of Kioto. The width of the river Kamo as it traverses the city is 120 yds.; but in common with other Japanese rivers, it has three threads of streams in ordinary seasons. In case of heavy rain the freshets come in. The area of the city is 18 English square miles. As to population, it has varied from time to time, and now it is only a half of what it is supposed to have been in the Middle Ages, when the old capital was flourishing. At present the number of houses is 66,000, and the population is 265,000. Nine broad streets run from east to west, which are called Tchijo, Nijo, Sanjo (First Avenue, Second Avenue, Third Avenue), etc. The broadest of these streets is 170 ft., while others are only half as wide. The city is divided into 1,216 squares, just like checkerboard, each being 400 ft. square. Accordingly, the location of buildings is designated in a very simple manner, like the co-ordinates in analytical geometry. As to bridges, the important ones are those which cross the river Kamo.

The site for the exhibition is in the northeastern part of the city, near the incline of the Lake Biwa Canal, which greatly adds to the beauty and advantage of the site. The exhibition grounds have an area of 1,807,200 sq. ft. (about 42½ acres), on which are erected the following buildings:

Industrial Building	151,200 sq. ft.
Machinery Hall	32,400 " "
Agricultural and Forestry Building	51,840 " "
Marine Products Building	19,440 " "
Aquarium	1,260 " "
Fine Arts Building	14,688 " "
Live Stock Building	21,600 " "
Ceremonial Hall	12,960 " "
Total	305,388 sq. ft.

In addition to these principal buildings, there are attached buildings, such as post and telegraph offices, etc., which occupy an additional area of 70,497 sq. ft. Fig. 1 shows the bird's-eye view of the exhibition ground.

The exhibition was opened April 1. The total number of articles exhibited was 170,184, which was 8,111 more than those in the third national exhibition. (Among the articles exhibited

are embroidered goods, satin, many kinds of crape, fabrics, many kinds of silk, velvet, cotton cloths, cords and plaited goods, porcelain, cloisonné, metal wares, lacquer wares, gold lacquer, gold and silver foil, fans, tea, incense, ivory and wood-carving, sculptures, paintings, photographs, fine art curios, cabinets, machinery, all sorts of manufacturing, mining, agricultural, and marine products, etc.) On July 11 the medals and certificates were distributed to the meritorious exhibitors. The following are the gainers of the gold medal of honor:

Sano Silk Factory of Miyagi-Ken	For silk manufacture.
S. Mitsui	" coal mining in Miike colliery.
I. Furukawa	" copper mining and refining in Ashio copper mines.
K. Date	" agriculture in Hokkaido.
Shidzuoka Society of Tea Manufacturers	" tea making.

the exhibition lasting eighty days, commencing March 10. It was memorable as being the occasion for first giving passports by which foreigners, unconnected with legations, were able to go to the old capital. It was visited in May by the Emperor. The next four years it was held in the Imperial palace. In 1874 medals were for the first time distributed among exhibitors of deserving merits. In 1877 the exhibition was held in the palace of the Empress dowager, and was visited by her and the Emperor. It continued to be held there until 1881, when the new building ever since used was completed. The building is entirely of Japanese style, the whole exhibition ground comprising about 12½ acres. Among the articles exhibited are the specimens of high artistic skill and fine art curios.

The Memorial Buildings for the Celebration of the Eleven Hundredth Anniversary of the Founding of Kioto.—Though

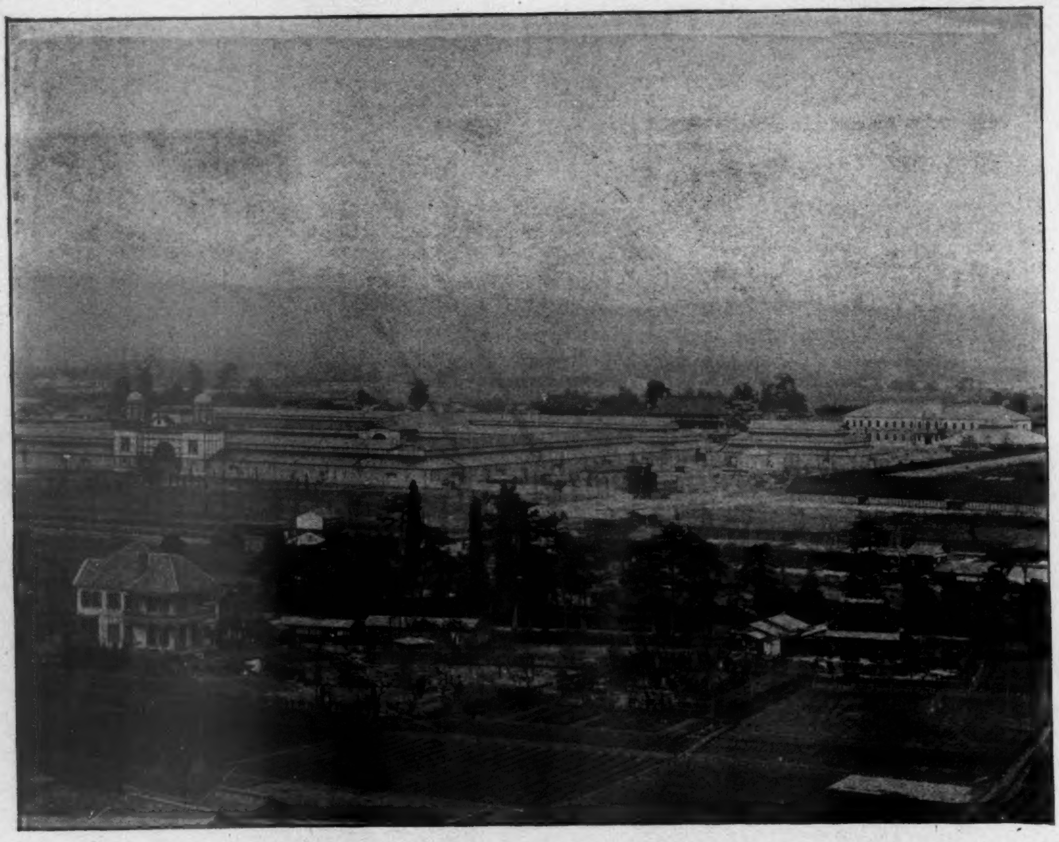


FIG. 1.—BIRD'S-EYE VIEW OF THE JAPANESE NATIONAL EXHIBITION IN KIOTO, FOR THE CELEBRATION OF THE ELEVEN HUNDREDTH ANNIVERSARY OF THE FOUNDING OF THE CITY.

Besides these gold medals, silver medals of honor were presented to 17 exhibitors, and 5,164 medals of different ranks, and 12,548 certificates were distributed to exhibitors of merit. Thus the gainers of prizes were increased also 1,169, compared with the last exhibition, which is comparatively greater than the increase of the exhibited articles, showing the progress of the agriculture and manufactures during the last five years.

The Kioto Imperial Museum and the Kioto Exhibition.—Until recently the Imperial Museum in Tokio was the only one in the empire. Kioto and Nara were, however, old capitals, and they contain many rare treasures, so that there have now been built in both of those cities museums under imperial protection. Among the objects sought are the development of art industries by collecting model specimens, the preservation of materials for historical investigation, and the maintenance of old temples through admission fees to the museums. The grounds have an area of 25 acres, of which the museum occupies about three-quarters of an acre. It was at first intended to erect a building of two or three stories, but finally one of a single story was chosen, to lessen the dangers of earthquake. The small number of windows also adds to the strength, while the light is received from the roof.

The Kioto Exhibition was in the southeast corner of the Imperial Park, and was under the management of the Kioto Exhibition Association. The first exhibition was held in the east Hongwanji Temple for thirty-three days, commencing with October 10, 1871. The next year three temples were used, the removal of the capital to Kioto occurred in 794, the formal occupation of the palace did not occur until 796. According to the Japanese method of reckoning, the eleven hundredth year since that crisis is 1895. Hence this date has been chosen for the commemoration of the founding of the city. The buildings called Kinenden (or the Memorial Hall) have been erected, and the spirit of the Emperor Kwammu is enshrined under the name of Heian Jingu. The grounds in which they are erected are north of the exhibition grounds, and have an area of 12½ acres. The buildings include a memorial hall, eastern and western corridors, two towers called Soriu-ro and Biakko-ro, and a large gate called Oten-mon. With their red pillars and green tiles they form a conspicuous group—that is, in striking contrast to the plain structures used for the exhibition. These buildings add an elegance to the exhibition, just as the Howodo buildings in the wooded island in Chicago did to the World's Fair.

The Memorial Buildings are separated from the exhibition grounds by a broad road running eastward from the north-western bridge of the compound. Crossing this road from the exhibition, the first structure which attracts the eyes is the imposing two-storied gate called Oten-mon (see fig. 2). This gate can be seen while looking through the northern archway of the Industrial Building. It faces the south, is 60 ft. long, 24 ft. broad, and 64 ft. high. From both sides extend low castle parapets planted with small pine-trees. Passing through a wide open space the Riubiden (a platform 408 ft. × 150 ft. and raised 2 ft. 5 in. from the surrounding

ground) is reached. It can be ascended by four flights of stone steps, the two middle ones being each 57 ft. 5 in. long, while those at the ends are each 44 ft. 10 in. long. The edge of the platform between the steps is adorned with a red lacquer railing having metal ornaments, similar railings being on the sides of the steps.

The Memorial Hall proper or Daigoku-den is the central building that faces the south. It is 110 ft. long, 40 ft. deep, and 54 ft. high, and stands on a platform 5 ft. high, which is ascended by three flights of stone steps. The roof is supported by four rows of pillars. The front is entirely open, while the other sides are plastered white, with three doors on the north side and one each on the east and west. Through the central door on the north there can be seen the Emperor Kwammu's shrine, which is in the rear. According to the custom of eleven centuries ago, the floor is paved with tiles. The two trees in front of the building and on the Riubi-dan are named, like the corresponding ones before the Shishinden of the Imperial palace, Sakon-no-sakura (cherry-tree on the left) and Ukon-no-tachibana (a tree of orange kind on the right).

There are two corridors attached to the Memorial Hall. The eastern is called Soriu-ro and the western Biakko-ro. Each is 139 ft. long, 13 ft. wide, 20½ ft. high, and stands on a platform 2 ft. high. The twin towers are of peculiar construction, the central tower supporting four minor ones. The height of each central tower is 45 ft. 8 in., and of the minor ones 34 ft. 7 in., while the base is 32 ft. 6 in. square.

These Memorial Buildings were designed by Mr. C. Ito, graduate of the Imperial University, and were built according to the style of the eighth century, so as to reproduce parts of the palace then erected by the Emperor Kwammu. However, the dimensions have been reduced, and only a few original edifices are represented. All woods used in the buildings are *ninoki*. Some of the characteristics of the building are as follows: 1. The style is very simple, without any carvings or pictorial ornamentations. 2. They are comparatively low, and give the impression of stability. 3. The rafters are elliptical instead of being rectangular in other buildings. 4. The peculiar terminals of roof called *shibi* (kite-tails) are used, which are only seen on Imperial palaces. They are said to have been used in China in ancient times. Those on the Daigoku-den are of copper and gilded.

The woodwork of the buildings is painted red with lead oxide, while the tiles on the roof have a green glaze; so that the group presents a striking and picturesque appearance in contrast with the modern style of buildings erected for the exhibition.

The Lake Biwa-Kioto Canal.—The canal is crossed by several bridges near the exhibition ground. The water power station and the incline along which boats with cargo are being moved up and down on wheeled cradles are as if they are exhibited machinery. The cradle is hauled by a steel rope passing round a drum, which is worked by electricity generated by the water power of the canal. At this incline the canal branches into two. The main canal for navigation descends 118 ft. in 1,815 ft. to the level of the city. The gradient of the canal incline is 1 in 15. Double lines of railways, consisting of flat-bottomed steel rails weighing 75 lbs. per yard on wooden sleepers, are laid. The gauge is 8 ft. 3 in. Two cradles, each with eight wheels, are so arranged that one goes up while another is descending. The width of the boat is 7 ft. and the length 45 ft., the weight of cargo being from 10 to 15 tons. The time of passage of the cradle is about twelve minutes.

The electric generating station is situated at the foot of the incline, near the Buddhist temple Nanzenji. Three iron pipes with a diameter of 36 in. are laid side by side. The total quantity of water to be used in the station is 240 cub. ft. per second, with a fall of 120 ft. When the full power is to be used, twenty 120-H.P. Pelton water-wheels are to be constructed. At present only half of the wheels are being used. The Pelton wheels are belted with Edison, Thomson-Houston, and Brush dynamos, with countershafts between them. Lately three-phase dynamo of Siemens & Halske was also laid. Not only are the cradles moved up and down the canal incline by the electric motor, but the electric power is used for spinning, weaving, in the manufactures of clocks, watches, needles, oil, lemonade, ice, soda-water factories, rolling mills, rice mills, for pumping water used in bath-houses, etc., which are situated within a circle of 2 miles from the power station. Besides these, the station supplies electricity in the daytime to the Kioto Electric Railway Company, and at night to the Kioto Electric Light Company. The cost of the power ranges from $20 to $60 per H.P. per year for daily rates of twelve hours; for eighteen hours the increase is 30 per cent., and for twenty-four hours it is 50 per cent.

The Lake Biwa is the largest lake in Japan, having an area of 500 square miles, and the canal begins at the southwest extremity of the lake in Otsu, and enters the first tunnel of 8,040 ft. long near the famous temple of Miidera, running along the sides of the hills of Yamashina, and piercing two other tunnels, of which the respective lengths are 411 and 2,802 ft. It is just below this third tunnel that the canal divides into two branches, of which the arrangement of the incline in the main canal has been already described. From the

FIG. 2—OTEN-MON (GATE FOR MEMORIAL BUILDINGS) FOR THE ELEVEN HUNDREDTH ANNIVERSARY OF THE FOUNDING OF KIOTO BY THE EMPEROR KWAMMU.

pool at the foot of the incline the canal continues westward and unites with the Kamo River canal. The canal turns to the east, passing a little south of the Kobe-Tokio Railroad as far as the Inari station, whence it turns toward Fushimi, and finally enters the Uji River. Of the total amount of water—300 cub. ft. per second delivered by the canal—240 cub. ft. goes to the main canal and the remaining 60 cub. ft. goes to the branch canal, which leads northward at the head of the incline through the fourth tunnel; then it crosses the valley of the Imperial tomb by a handsome viaduct of 14 arches; then, after passing two more tunnels, it crosses the Takano and Kamo rivers by siphons and continues to Kogawa. The length of the canal is 27,690 ft. The chief object of this branch canal is the irrigation of rice-fields, though partly it is used for power, while the object of the main canal is to open the navigation and to produce electric power. The length of the main canal is 36,650 ft., and the difference of the level is 140 ft. Of this difference of level, 129 ft. are arranged with a lock and incline, while the remaining 11 ft. by the gradiant, varying from 1 in 2,000 to 1 in 3,000.

The construction of the canal was proposed by Mr. K. Kitagaki, governor of Kioto-fu, in 1881, when the fortunes of the city were at the low ebb. As the city, which for ten centuries had been the capital of the empire, was robbed of much of its former grandeur after the seat of government was removed to Tokio in 1868, it was thought that the new canal would certainly do much to restore its prosperity. In order to attain this aim, Governor Kitagaki took the necessary measures in carrying out the work, Professor S. Tanabe, of the Imperial University, being engineer-in-chief. The work was commenced in August, 1885, and was completed in 1891. The total cost of the work amounted to nearly $1,000,000, which is the property of the city, though having some public debt.

The work of the Lake Biwa Canal, indeed, added a new elegance to the natural scenery, ancient temples, and artistic skill of the inhabitants of Kioto. In this memorable year for commemoration of the founding of the city, while the national exhibition was being held, it is a remarkable fact that Kioto became a military headquarters of the victorious war with China, when the reigning emperor was in the old palace. There was a great influx of people not only from different parts of the empire, but also from foreign lands, who were attracted thither by the fame known in the Columbian Exposition. It is a noticeable thing that while Japan was gaining brilliant victories in the war with China, she did not neglect to prepare for the industrial exhibition, in which her great progress made in manufactures and arts within the last five years was shown.

STANDARD CARS ON THE SOUTHERN PACIFIC RAILROAD.

WHAT may be called the mechanical situation existing on the lines constituting the Southern Pacific system differs from that on other large railroad systems, in that the jurisdiction of the Superintendents of Motive Power of any one of the properties making up the lines of the system does not extend beyond the rolling stock of his particular line; first, by reason of the great distance between the principal shops on the lines (it taking four days for a letter from Houston to Sacramento); and, secondly, the State of Texas requires that each company chartered in the State shall be operated by its own officers. This has made it somewhat more difficult than ordinarily is the case on other roads to establish and maintain standards in rolling stock, so essential on properties where there is so large and so constant an interchange of cars between the lines of the system. This is particularly true in the State of Texas, where in freight trains of the several lines are frequently hauled cars of all the other lines. An arrangement, however, has recently been perfected by which all the lines concerned co-operate in the establishment and maintenance of common standards, and the following circular is the first step in that direction.

Among the difficulties experienced in this matter (undertaken some three years ago) was the differing opinions of the officers of the mechanical departments of the different lines about details of construction, and the absence of definite information on the service of the details on cars already in use. It frequently occurred that, no sooner had a new lot of cars been built on previously agreed specifications, than the mechanical department of one of the lines would suggest improvement or put in use an improvement on his own line, considering only the apparent benefits of the improvement for his own line, without considering its effect on the other lines or the disadvantages which might result from disturbing existing standards. In some instances the causes for changes made were mainly incidental, and would occur but seldom in the ordinary course of business.

This state of affairs resulted largely from the fact that the officers of the mechanical department of each line were governed only by the experience of their own particular line, and proceeded to make changes without reference to the effect on the properties as a system. As already stated, it required days to hear from the mechanical officers of the other lines, and they had no time to give these matters the consideration to which they were entitled.

In issuing the following circular it was not intended to check improvement which is constantly being made in rolling stock, but to proceed in a systematic manner, making improvements only from as correct information as can be obtained on questions affecting proposed changes in established standards.

The following is the circular referred to:

SOUTHERN PACIFIC COMPANY.

MOTIVE POWER STANDARDS.

NEW YORK, May 18, 1895.

By July 1, 1895, there will be in service about 1,300 freight cars built upon common standards, in accordance with the circular letter of the President, of December 7, 1894, providing for the establishment and maintenance of common standards in rolling stock and motive power.

It is now desired to determine by careful observation the merits of the cars built under these standards, and such other rolling stock as may hereafter be built under common standard specifications; and remedy as far as practicable all deficiencies in construction which may manifest themselves in the use of common standard rolling stock, perfecting by these methods the designs for common standards and bringing the equipment up to the highest degree of efficiency. The data, in respect to the service of these cars and other common standard rolling stock, can only be ascertained from the character of the current repairs made. These repairs are distributed over about 8,500 miles of railroad; and some systematic method for the collection of information, regarding the character of the repairs made, will be necessary to make the information available and valuable for the above purposes. It has, therefore, been arranged:

1. All cars or other rolling stock built under common standard specifications will be known by the designation $\boxed{\text{C. S.}}$ This designation will, on the freight cars herein referred to, be found under the medallion, and to the right of the words "Westinghouse Air Brake;" thus $\boxed{\text{C. S.}}$

2. At all shops or junction points of the roads concerned where running repairs are made, a report is desired on a blank furnished for that purpose [Form C. 38], of the general character of repairs, and particularly renewals made on such cars. The information desired in respect to such repairs and renewals is:

(a) The particular part repaired or replaced.

(b) The location of fracture or breakage, and cause, as far as this can be correctly described.

(c) The total number of hours of all men employed in making said particular repair, as nearly as this can be given.

3. The above applies only to repairs incident to current use of the cars, and not to cars wrecked or damaged by derailments and collisions, or causes other than those incident to the general service in train or in yards.

4. These reports should be forwarded from the division or junction shops to the Superintendent of Motive Power and Machinery, at the close of each month, or at such other intervals during the month as the Superintendent of Motive Power and Machinery may direct. As early as practicable thereafter these reports should be forwarded by the Superintendent of Motive Power and Machinery to the Mechanical Engineer, with such recommendations in the matter as will in his judgment be of benefit to the service.

5. The above applies to all cars and other rolling stock of the Southern Pacific Company and affiliated lines, stencilled $\boxed{\text{C. S.}}$, regardless of the initials thereon of company owning it.

The above arrangements will assist largely in forming a correct conclusion about the wear and service of existing standards, and in what direction and to what extent it is desirable to make improvements in them. If the monthly reports of Superintendents of Motive Power and Machinery are supplemented as occasion arises by their observations in respect to the common standards in use, they will, by these measures of observation, secure in time standards in rolling stock which will increase largely its service to the public and general efficiency, and reduce the cost of its maintenance.

WILLIAM MAHL,
Second Assistant to President.

NOTES AND NEWS.

Andrew Carnegie has aroused British wrath by saying that it would pay England to burn up her railroad equipment and replace it with American models.

The Siberian Railroad from Lake Baikal to Vladivostock is now completed; the route runs further south than was originally planned. Of the 6,000 miles between St. Petersburg and Vladivostock, 2,300 are now built and 3,700 remain to be completed.

Fast Torpedo-Boats.—It is reported that the British Admiralty has placed orders with the Messrs. Thompson, shipbuilders, of Glasgow, for the construction of three torpedo destroyers capable of maintaining a rate of speed of 36 land miles per hour. The intention is that these boats shall be the fastest vessels of their kind afloat.

Prizes for Essays on Profit-Sharing.—Two prizes of $5,000 each, for essays on profit-sharing and on trade-unions, open to persons of any nationality, are offered by Comte de Chambrun, the endower of the new Social Museum in Paris. The essays on profit-sharing must be handed in before December 31, 1896; those on unions before December 31, 1897, to the Société des Études Sociales in Paris.

Russian Naval Notes.—During the past few months four Russian armored ships have been launched. This has not stopped the activity of Russian State naval departments. The launched ships are now supplied with engines and armament, and on the slips upon which these were built four new ships have been begun. The first-class armored ship *Sisoï the Great* received the boilers and engines made by the Baltic works, and a portion of side armor of the lower citadel, in the summer of 1894. The engines will be tested during the coming summer.

The Armored Cruiser "Dupuy-de-Lome," 6,300 tons, has, after repeated alterations, again failed to answer satisfactorily the demands made on her. She is a long narrow vessel with three screws, and the three sets of engines constantly hamper one another. This vessel was launched in 1890, and is still in the experimental and alteration stage. *The Times* says: "The Americans have had greater success with three screws in the *Minneapolis* and *Columbia* class, but those vessels, in addition to greater lengths, have nearly 7 ft. more beam than the *Dupuy-de-Lôme.*"

Locomotive for the State Railways of Hanover.—We are in receipt of a letter from Mr. August von Borries, stating that the express passenger locomotive, as illustrated by us in our issue for June, was not built by him, as we asserted, and that if it had been, he would have built it as a compound. The design will be so constructed in the future because it now uses a great deal of coal, and is not sufficiently efficient to do the work that it is called upon to perform.

Failure of the "Columbia's" Boilers.—During the speed trial of the cruiser *Columbia* across the Atlantic, Captain Sumner reported: "It was not deemed practicable to make the last 24 hours run under forced draft because of the unreliability of the boilers (we were blowing out tubes at 140 lbs. pressure), the loose state of the engines from the long run, the great fatigue of the crew, and, above all, the impracticability of getting a coal supply to the boilers with sufficient rapidity, as the coal was located at this stage of the run."

Power without Shafting.—An indication of a tendency toward the construction of shops without shafting is given by the erection of a power building in Pittsburgh designed for occupancy by a large number of small manufacturers. No belting, shafting, or pulleys will be used, but a complete system of electric motors will be installed upon each floor. It is also announced that the locomotive works at Düsseldorf, Germany, have been using electric motors for almost a year in the foundry, resulting in a large saving over the former method of using belts.

The Heilman Locomotive.—The French Western Railway Company has made arrangements with the Heilman Company for two electric locomotives of 108 tons 5 cwt. 1.012 qrs., capable of dragging 196 tons 16 cwt. 3.295 qrs. at the speed of 62 miles per hour. *Railway News*, quoting from the *Journal des Transports*, says these locomotives, the power of which will be triple that of the one tested last year on the Nantes Line, are intended for the Paris-Dieppe Line, and the company hopes to be able at the end of next June to make the journey in two hours.

Endurance of Wire Rope.—A rope of Cradock's improved crucible steel, an inch in diameter, after fourteen years' constant use, during which it was never repaired, though it has hauled 1,500,000 tons, has been taken out of a Nottingham colliery; another steel rope, 3,400 yds. long and 2¼ in. in circumference, was used continuously in a Sheffield colliery for eleven years and eight months; a third rope, 392 yds. long and 5 in. round, was used on the under side of a drum, near Barnsley, for three years and ten months, lifting 735,679 tons of coal in that time.

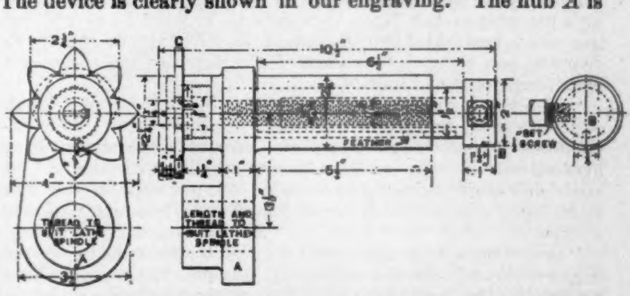
New Russian Imperial Yacht.—This, it is said, will be the largest yacht ever constructed, and was to be launched on the Czar's birthday. It will be of 5,300 tons, while the length is 430 ft. *Pole Star*, the present imperial yacht, is 2,000 tons less, and is only 350 ft. long. The new yacht has engines of 12,000 I.H.P., to give a speed of 20 knots at sea, while the old yacht had engines of only 6,000 I.H.P. The new yacht, too, will have Belleville water-tube boilers. The keel-plate was laid in the summer of last year by the late Czar, and the cost is put at £400,000. She is named *Standard*, and will have a complement of 370 officers and men.

To Prevent Waste of Electricity.—The Baltimore *Sun* says that an inventor in that city has devised an insulated conductor of electricity for railways operated by the underground system. In reference to his invention he says:

"Its object is to prevent the enormous waste of electricity to which all underground railway lines are subject on account of dampness in the conduit and the large amount of iron with which the conductor is surrounded. This is accomplished by partly covering the conductor, which is a bar of steel, with enamel similar to that used on kitchen utensils known as granite ware. The substance is virtually glass, one of the best non-conductors known."

Timber Water Pipe.—Some interesting details are given of the construction of the water-works of Denver, Col., a notable innovation consisting in the laying of 16 miles of 30-in. wooden conduit, also a considerable length of 44-in. pipe. The timber used for this purpose is California redwood, and the 30-in. conduit is adapted to stand under a head of 185 ft. In this work the mains were composed of staves dressed very smooth to cylindrical sides and radial edges, being held to the cylindrical form by mild-steel bands placed at a distance apart, depending upon the head, but never exceeding 17 in. The pores of the wood are filled with the water under pressure, so that it oozes through to a slight extent, thus insuring permanent preservation, and the interior finish is so smooth that the most advantageous conditions of flow are secured.

Device for Turning off Lifting-Shaft Journals.—In the turning off of lifting-shaft journals for locomotives, the size of the work and the size of the lathe upon which the said work is done are usually out of all proportion with each other. To use a lathe large enough to swing the shaft is an awkward way of doing the job, and yet to use a tool of smaller size a special wrinkle of some sort is required. Such a wrinkle is in use in the shops of the Baltimore & Ohio Railroad. Its principle lies in that the cutting tool is fastened to the live spindle of the lathe and the shaft held stationary between the centres. The device is clearly shown in our engraving. The hub *A* is



DEVICE FOR TURNING OFF LIFTING-SHAFT JOURNALS.

screwed upon the spindle, and on the elongation at *B* there is a tool-holder that is moved in and out of the sleeve by the screw feed driven by the star motion at *C*. A centre with a long shank is put in the spindle, coming out far enough to carry the end of the shaft beyond the tool that is held at *B*, when the tool-holder is screwed home. The shaft is placed on the centres, and the tool revolved about it. In this way the job can be done on a lathe of ordinary swing and much smaller than that which would otherwise have to be used.

Deficient Stability of French Ships.—"Many of the French fighting ships have shown deficient stability, and their superstructures and military masts are being rapidly removed. This is being done to the *Magenta* at Toulon, and at Brest the *Hoche* and the *Brennus* will be in dockyard hands for many a day, the after fighting mast in both cases being bodily removed; and the *Charles Martel*, now building, is to be altered in the

same way from the original design. The cruiser *Friant* has had both masts cut off as low down as the bridge; thus she loses four machine guns previously placed in her fighting tops. As this vessel was altogether overweighted and floated deeper than her design, she is to have four torpedo-tubes and the proportionate torpedoes and all the heavy gear appertaining to them discarded, and the crew is to be lessened. The *Lansquenet* has again broken down on trial.—*The Times.*

Brick-dust Mortar.—The use of brick-dust mortar as a substitute for hydraulic cement, where the latter cannot be obtained, is now recommended (the *Southern Architect* says) on the best engineering authority; experiments made with mixtures of brick dust and quicklime showing that blocks of ½ in. in thickness, after immersion in water for four months, bore without crushing, crumbling, or splitting, a pressure of 1,500 lbs. per square inch. It is considered, too, that the addition of even as small a proportion as one-tenth as much brick dust as sand to ordinary mortars is preventive of the disintegration so often characterizing mortars used in the masonry of public works. The use of brick dust mixed with lime and sand is said to be generally and successfully practised in the Spanish dominions, and is stated to be in all respects superior to the best Rosendale hydraulic cement in the construction of culverts, drains, tanks, or cisterns, and even roofs, whether for setting flat tiles or for making the usual tropical flat roof. The proportions used there in the manufacture are, approximately, one of brick dust, one of lime, and two of sand, mixed together dry and tempered with water in the usual way.

The "Alert" and "Torch," the new sheathed sloops, sister vessels of 960 tons displacement, were successfully floated out of dock at Sheerness Dockyard recently. Built from the designs of Mr. W. H. White, C.B., Director of Naval Construction and Assistant Controller of the Navy, the *Alert* and *Torch*, which represent a new type of sloop, were laid down in No. 2 dock on December 7, 1893. They have been built with steel plating ½ in. thick, which is covered with teak wood sheathing, 3½ in. thick, to a height of 2 ft. above the water-line. The stern and rudder posts are of phosphor bronze, and were cast at Sheerness Dockyard. They have no armored protection, but a steel water-tight deck runs above the boiler and engine-rooms, and also forms a division between the upper and lower coal bunkers. Their principal armament will consist entirely of quick-firing guns, the vessels having been designed to carry six 4-in. guns and four 3-pdr. guns, together with two machine guns. Their engines and boilers, which have been made at Sheerness Dockyard, have been designed to register 1,400 H.P. under forced draft, with a speed of 13.25 knots, and 1,100 H.P. under natural draft, with a speed of 12.25 knots. They will be fitted with three masts and will carry yards on the fore and mainmasts.

The Most Important Recent Improvement in Firearms.—In reply to an inquiry made to General Schofield recently by a reporter of the New York *Sun* as to what he considered the most important improvement in firearms in the seven years he has been at the head of the Board of Ordnance and Fortifications, he promptly said:

"The rifled guns and rifled mortars for batteries are by all odds the most important of recent improvements. The importance of these long-range guns for coast defence cannot be overestimated. The rifled mortar, which, with the aid of position finders, can drop its missiles into a vessel three or four miles out from shore, is the most effective protector of our coasts.

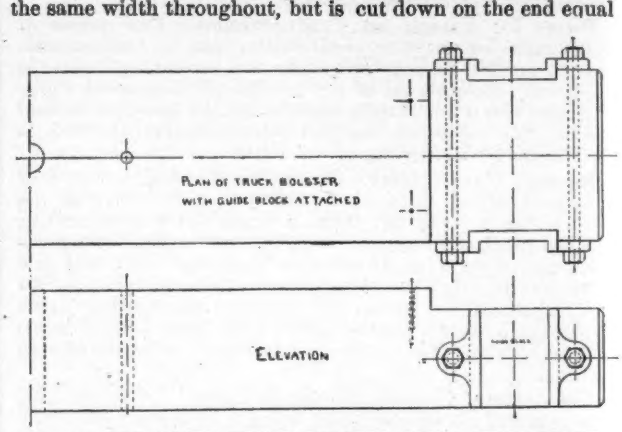
"Some persons might say that the torpedo boats, in the construction of which such a great advance has recently been made, deserve first place in a list of modern improvements. Certainly they form a factor of increasing importance in the problems of war."

A Sea-Monster of the Olden Time.—Is it true that our ram battleships are but old inventions in new forms? It looks like it. Some one has unearthed a curious announcement which appeared in the *Mercurius Politicus* for December 6, 1653—that is, two hundred and forty years ago—to the effect, as stated by the Dundee *Advertiser*, that "the famous monster called a ship, built at Rotterdam by a French engineer, is now launched." In a description of the vessel its capabilities are thus detailed:

"1. To sail by means of certain instruments and wheels (without masts and sails) as swift as the moon, or at least 30 miles every hour. 2. Both ends are made alike, and the ship can be stop'd at pleasure, and turned as easily as a bird can turn. 3. In time of war it can, with one bounce, make a hole under water in the greatest man-of-war as big as a table, and in an hour's time will be able to sink 15 or 16 ships, and in three or four hours will destroy a whole fleet. 4. She will be able to go to the East Indies and back again in eight or nine weeks. 5. She may be used to kill whales in Greenland, so that 100 ships may be laden in fourteen days. 6. She may be used to break down any pier or wooden work with great ease."

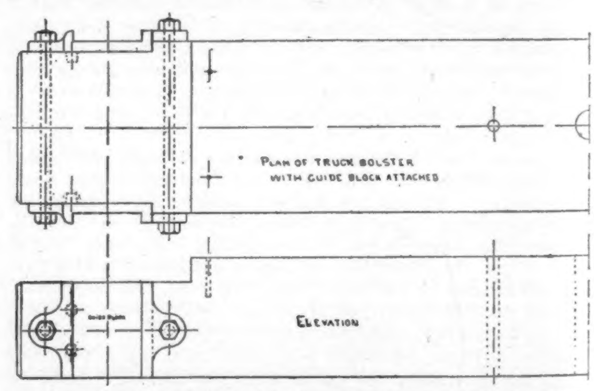
A wonderful "monster" this must have been. What, one is curious to know, was her fate?—*Exchange.*

Bolster Guide Block for Freight-Car Trucks.—The attached sketches show the plan and elevation of a truck bolster used in freight-car trucks with bolster guide-block attached. Sketch No. 1 shows the old style truck bolster and guide-block, in which it can be seen that the bolster is the same width throughout, with simply the two spaces cut out to allow the guide-blocks to fit in and takes two bolts of same length for each end to hold guide-blocks. Sketch No. 2 shows the new style truck bolster and guide-blocks. This bolster, is not the same width throughout, but is cut down on the end equal



No. 1. OLD STYLE TRUCK BOLSTER WITH GUIDE-BLOCK.

to the amount the guide-blocks set in the old style bolster, and the flange on guide-block is changed accordingly, which necessitates the use of a shorter bolt through the end of bolster, but is fully balanced by doing away with the never-ending complaint regarding the split-off ends of truck bolsters, and car inspectors at interchange points refusal to receive such cars without defect cards. When the ends split off of truck bolsters



No. 2. NEW STYLE TRUCK BOLSTER WITH GUIDE-BLOCK.

all that is necessary to apply the new style guide-block is to true up the surface against which guide-block bolts, bore two holes for the steady pins, and by using one short bolt in connection with one long bolt, as shown, the work is accomplished and it makes a very neat appearance.

The Action of Fly-wheels.—An interesting experiment is described by M. V. Bablon, who in the endeavor to secure the more uniform running of a dynamo driven by a gas engine, first proceeded to determine the amplitude of the angular displacement of the fly-wheel relative to the normal position it should occupy if speed were invariable. The fly-wheel was illuminated by means of a Geissler tube, excited by a Ruhmkorff coil, regulated so that its flashes coincided with the frequency of the passage of the fly-wheel arms through a given position. So long as the fly-wheel velocity was constant, the arms were visible at this instantaneous position by the light of the flashes, and the wheel appeared to be stationary; but as the velocity varied and the wheel ran slower, it appeared to have a slow retrograde movement, for the arms did not reach the given position at the moment of flash. Then, a fresh ex-

plosion taking place, the wheel would appear to slowly reverse its movement and overrun the flash point. In fact, the wheel appeared to swing slowly between two extreme positions, and its angular movement was easily measurable, the eye grasping readily the progress of the alternate advances and retrogressions. In light running, with one explosion every four or five cycles, the maximum angular movement was 50°. With load on, and only one explosion missed out of four or five possible, the angularity was 8° for successive explosion cycles, and attained barely 12° after a non-explosive cycle followed by explosion.

Hodgkins Prizes Awarded.—In 1891 Thomas George Hodgkins, of Setauket, N. Y., established a fund which was placed in charge of the Smithsonian Institution at Washington, and, according to the New York *Sun*, specified that the income from a part of this fund was to be devoted to the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man.

An announcement of the prizes which were offered was made by the Secretary of the Smithsonian Institution on March 31, 1893. The offer of a prize of this value excited general interest throughout the civilized world, and papers were received from nearly all those who were at all interested in this branch of scientific research.

The Committee of Award for these prizes has completed its examination of the 218 papers submitted in competition by contestants from almost every quarter of the globe, and has made the following decisions :

First prize of $10,000 for a treatise embodying some new and important discoveries in regard to the nature or properties of atmospheric air, to Lord Rayleigh, of London, and Professor William Ramsay, of the University College, London, for the discovery of argon, a new element of the atmosphere.

The second prize of $2,000 was not awarded, owing to the failure of any contestant to comply strictly with the terms of the offer.

The third prize, of $1,000, to Dr. Henry de Varigny, of Paris, for the best popular treatise upon atmospheric air, its properties and relationships. Dr. de Varigny's essay is entitled " L'Air et La Vie."

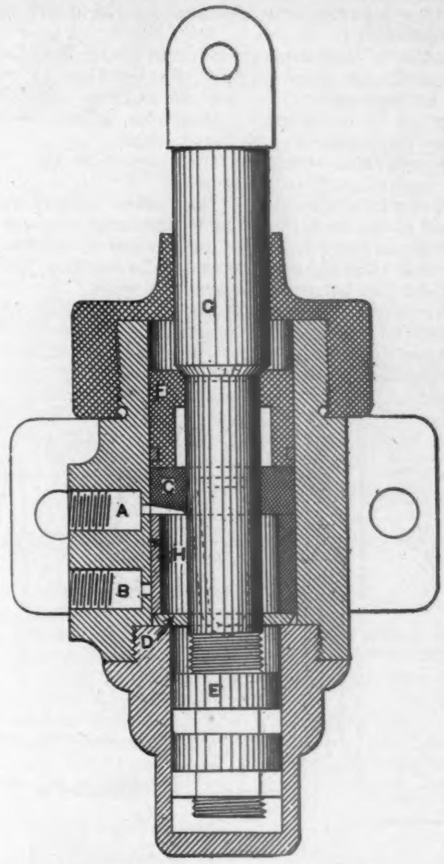
A considerable number of papers submitted in competition received honorable mention, coupled in three instances with a silver medal, and in six with a bronze medal.

A Trial of the British Torpedo-boat Destroyer "Boxer," built and engined by Messrs. J. T. Thorneycroft & Co., was made recently. The vessel proceeded to the trial ground, where six runs on the measured mile were made with the following results :

Time.		Speed.	Revolutions Starboard.	Revolutions Port.
Min.	Sec.			
2	2.6	29.364	425.7	400.3
2	4.4	28.939	420.5	419.6
2	1 4	29.654	415.1	407.7
2	9	27.907	408.3	406.0
1	58.6	30.354	418.3	411.8
2	9.8	27.735	411.4	410.0

The mean speed during three hours' running, as measured by the total number of revolutions made, was 29.17 knots ; the total distance covered in that time being 100.6 statute miles. This speed exceeds that ever obtained on an official trial by more than a knot. The four vessels of the class—namely, the *Daring*, *Decoy*, *Ardent*, and *Boxer*, all built by Messrs. Thorneycroft & Co.—have each beaten the record in turn and are now the four fastest ships in the world.

A Locomotive Bell-Ringer.—The accompanying illustration shows a very simple form of bell-ringer that is in use on some of the Western roads. It may be operated by steam or compressed air, though the latter is to be preferred, in that it requires no special piping for the exhaust and any leakage that may occur does not disfigure the jacketing or the engine. The ringer is placed at the bottom of the bell-bracket in an upright position, just as it appears in the engraving. The steam or air is piped to enter at A. When the bell is standing the pressure is exerted upward against the ring C, which crowds against the piston F, and through the latter upon the stem G. The stem G is connected to the crank of the bell by a rod, and as long as this crank is in the vertical position it is on the dead centre, and the bell does not ring. By pulling on the bell-cord the crank is swung off from the dead point, and an upward thrust given to it by the steam or air. The piston F is thus pushed up to the upper limit of its stroke, and an impulse given to the bell that carries it beyond, causing the stem G to rise away from the piston F. In doing this the piston E is raised until it strikes the ring D, which with the shell H is lifted until the exhaust-port B is uncovered. When gravity overcomes the upward motion of the bell and it swings back the steam or air that has been imprisoned within the shell H expands and causes the plate D to follow the piston E down, and thus open the exhaust B, while H remains to



A LOCOMOTIVE BELL-RINGER.

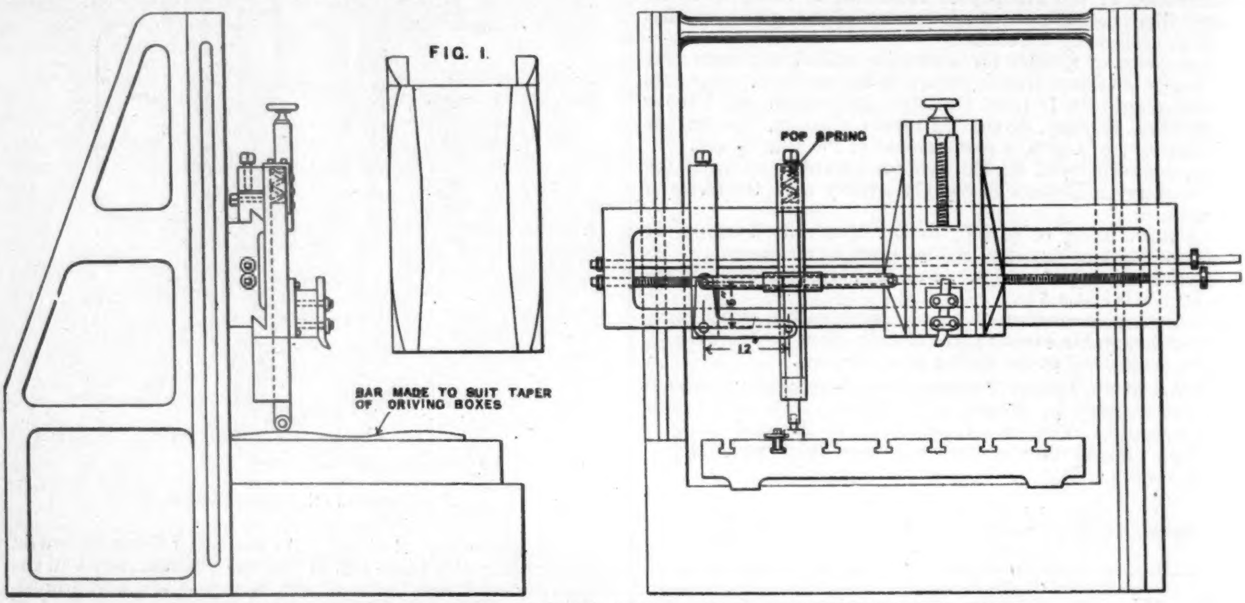
keep the steam-port A closed. As the bell reaches its lowest point the ring H is again forced into the position shown in the engraving, and the admission port is opened to admit a pressure below the piston and give an upward impulse to the bell as it swings in the other direction. The connections are so made that there is no chance for binding, and the bell is free to swing over and over should the upward impulse be sufficient to cause it to do so.

Plans for the New Battleships.—The main features of the plans for the two battleships authorized by the last Congress have been decided upon. Two of the main points were settled by Secretary Herbert himself, and the others were referred by him to the Board of Bureau Chiefs for settlement. The Secretary's decision was contained in a letter which he sent to the Board of Bureau Chiefs. It stated that he had come to the conclusion that double-deck turrets and 13-in. guns were best fitted for the new ships, and referred the question of raising the armor belt 1 ft., as proposed by the Ordnance Bureau, to the Board for settlement. The Board immediately took up the Secretary's letter, and after considerable discussion it was decided to design the ships with the bottom of the belt 5 ft. 6 in. below the water when the draft of the vessel was 25 ft., the extreme draft set by the Secretary. The dimensions of the new battleships are as follows : Length, 368 ft.; beam, extreme, 77 ft. 2 in.; mean draft, 23.50 ft.; extreme draft, 25 ft.; normal displacement, 11,500 tons ; speed, 16 knots, with 1 in. air pressure. The armament for each consists of four 13-in., four 8-in., and sixteen 5-in. rapid fire guns. Regarding the weight to be allowed to the Bureau of Steam Engineering, it was limited by Secretary Herbert in his letter to from 1,000 to 1,200 tons. It was claimed by Chief Naval Constructor Hichborn that 1,000 tons would be all that was necessary to produce 9,500 H.P., the amount required to drive the vessel 16 knots under 1-in. air pressure, the speed wanted by the Secretary.

Engineer-in-Chief Melville, however, says that in order to obtain strong machinery 1,200 tons must be allotted to him. The Board of Construction settled the controversy, in which a compromise was made, the Board deciding to allot 1,100 tons of this department with 10,000 H.P.

Reports of Railroad Accidents.—A committee appointed by the British Board of Trade to report whether any improvement is possible in the shape in which information is supplied by railway companies and tabulated by the Board of Trade has recommended:

1. That the railway companies report to the Board of Trade all fatal accidents occurring in the working of railways, whether to passengers, servants of railway companies, or other persons, by telegraph or otherwise, within twenty-four hours after the occurrence of the accident.
2. That non-fatal accidents be reported to the Board of Trade by post as early as practicable.
3. That non-fatal accidents to servants of railway companies be reported to the Board of Trade whenever they are such as to prevent the servant injured, "on any one of the three working days next after the occurrence of the accident, from being employed for five hours on his ordinary work."
4. That non-fatal accidents to persons other than servants of the companies be in all cases reported to the Board of Trade, as it is impossible to apply the above measure of the gravity of an accident in the case of such persons.



PLANER ATTACHMENT FOR PLANING THE FLANGES OF DRIVING-BOXES TAPER.

5. That the instructions hitherto given by the Board of Trade to railway companies, as to the classes of accidents to be reported, be withdrawn.
6. That the model form of return issued by the Board of Trade be amended so that the railway companies may be required to state the following additional particulars:

(*a*) The time of day at which the accident occurred; and where the person killed or injured is a servant of the company;

(*b*) Whether he was an adult or a minor (persons of and above eighteen years of age being treated as adults);

(*c*) His regular working hours; and

(*d*) The number of hours he had been on duty when the accident occurred; and that a note be appended to the form of return requesting the companies to give full and precise descripions of accidents and of the causes of accidents so far as possible.

7. That the railway companies should furnish to the Board of Trade, for publication with the periodical returns of accidents made to Parliament, annual statements of the number of persons employed in each department of their undertakings.

Planer Attachment for Planing the Flanges of Driving-Boxes Taper.—On some roads it is customary to taper both flanges of the driving-boxes of the locomotives on the inside, as shown in fig. 1 of our illustration, in order to allow the box to be down on one side and up on the other without pinching the flanges against the pedestal shoes and wedges. A convenient wrinkle to do this, at one setting of the planer, is in use in the shops of the Baltimore & Ohio Railroad, and is shown by the accompanying engraving. It consists of a template bar bolted to the platen of the planer, upon which there rides a bar having a wheel set in its lower end that is forced down upon the template by the spring at the upper end of the bar. Connected to this upright bar there is a bell-crank, whose other arm is connected to the head of the planer by a rod that has a right and left-hand nut at the centre for adjusting the head and the tool to the work. It will be seen that when the platen of the planer travels back and forth a motion will be imparted to the vertical bar, which is in turn communicated to the head of the planer through the bell-crank connections.

Tests of Turrets and Side Armor.—The Navy Department is arranging for an armor test such as has never been made before. The test will be made some time the last part of this month, and is expected to determine as nearly as possible the exact effect produced on a modern turret by the attack of the heaviest guns carried by the new battleships. To effect this test there will be erected on the proving ground at Indian Head a turret such as will be carried by the battleship *Indiana.* This turret is now making at the Cramp Shipyard in Philadelphia.

It will be constructed with all the resisting qualities, backing, and framing which the turrets of the battleship *Indiana* will have when installed. The framework, when completed, will weigh 63 tons. Around this structure will be placed the 18-in. armor plates of the *Indiana's* turrets. One of these plates, however, will be the one which was fired on at Indian Head at the acceptance trials of the *Indiana's* armor. This plate will be used for the attack because of the great cost involved in using a new plate.

The total weight of the turret when mounted on shore will be about 500 tons. It will be a facsimile of a real turret in all respects, save for the absence of the two 12-in. guns. Their weight will be made up by old plates and broken steel, so as to bring the turret up to the weight it would have when installed on shipboard.

When this turret is completed two shots will be fired at the injured plate from the 12 and 13-in. rifles. The department officials expect to be able to determine from this experiment practically what the actual effect produced on such a turret by such an attack in actual battle would be. The experiment will probably result in some valuable lessons in ordnance work, and may lead to improved methods of mounting turrets or strengthening interior parts.

Besides this test, there will be made a test of the resisting power of a ship's side when protected by 15-in. armor. An exact reproduction of a ship's side will be put up on the proving ground. Every beam and rivet will be placed in the experimental side which the ship would have when the armor was in place. This experimental side will be protected by 15-in. Harveyized armor, such as will be placed on the battleship *Iowa*, and the attack will be made by the heavy rifles.

The conditions under which the guns will be fired for these experiments will approximate those which would obtain if the real ships were attacked at a range of about 4,000 yds., or the fighting distance of the contending fleets at the battle of the Yalu.—*New York Sun.*

THE LAVAL STEAM TURBINE.*

By M. K. Sosnowski.

I beg to call your attention once more to this machine, which has passed beyond the realm of a laboratory curiosity and entered the field of industrial appliances. All of the objections that were made to it at the outset, and to which we could only offer our statements to the contrary, have been refuted by actual performances; all apprehensions and fears have been dissipated by a year's service in France and three years abroad.

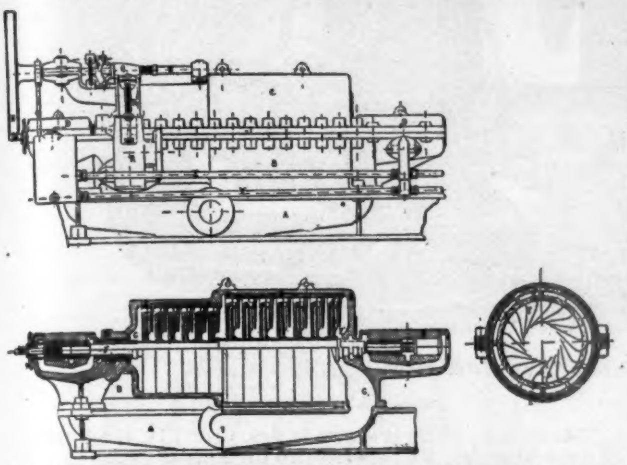


Fig. 1.—Elevation, Longitudinal and Cross-Sections of Parsons' Centrifugal Turbine.

It is needless for us to recapitulate the method of utilizing the energy of steam by the use of pistons in the ordinary steam engine, where the motion is rectilinear or rotary. With multiple expansion condensing engines, the maximum economy realizable with this class of motors has been obtained. The actual efficiency is still low on account of transforming the caloric energy into mechanical energy. The losses in efficiency are due to incomplete expansion, to the action of the walls of the cylinder and to other secondary causes which do not permit even the very best steam engines to exceed a third of the theoretical efficiency of the Carnot cycle, which, in its turn, only represents a quarter of the potential energy of the fuel.

In the Laval turbine the two main causes of the low efficiency of piston engines are fortunately quite restricted. We

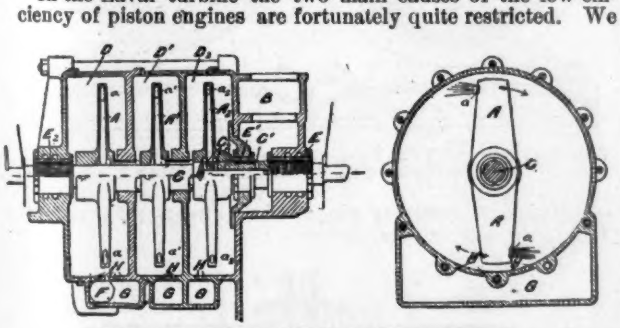


Fig. 3.—Parsons' Reacting Turbine.

cannot say that it is the first attempt in this direction, but we can say that it is an attempt that has been crowned with a real success.

Without going too far—for, as in everything else, we can here find very ancient precursors—and without entering too much into details, we will give a brief history of similar apparatus in order that we may better show the difference between the apparatus under consideration and its congeners.

Parsons' Turbo-Motor (1884).

The first Parsons turbines were of the Jouval type, with a circulation parallel to the axis of rotation. They are characterized by the fact that the fall of pressure is not made at once, but takes place gradually in passing through a series of fixed distributors and turbine wheels. It resulted in the necessity of reducing as much as possible the play between the fixed and movable parts, in order to lessen the loss of steam. In the more recent turbines the steam acts radially, either centripetally or centrifugally.

* Paper read before the Society of Civil Engineers of France.

Centripetal Turbine (1890, fig. 1).—The cylinder of the turbine is in two parts, B and C, bolted together. The shaft J', which runs through it, carries a series of movable wheels of different diameters, in order that the expansion may take place on the compound principle, from one series to another. All of them have the radiating wings F. The directors E are fastened to the half cylinders B and C. In order to lessen interior leakages and to compel all the steam to pass through the tur-

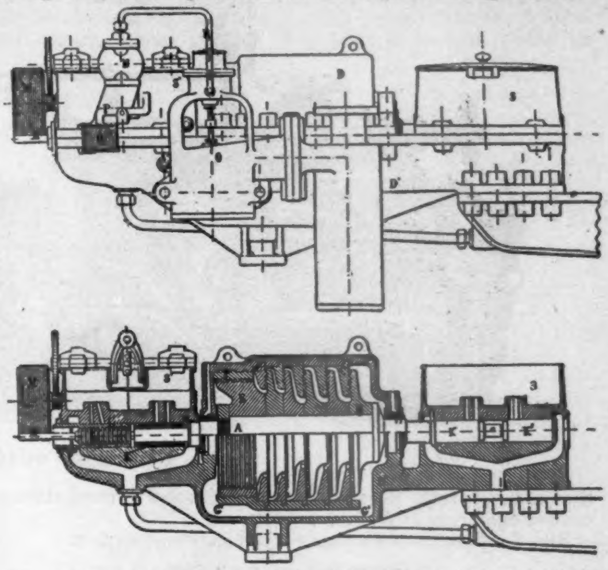


Fig. 2.—Elevation and Longitudinal Section of Parsons' Centrifugal Turbine.

bines, the turning parts are carefully adjusted so as to allow just enough play to avoid frictional resistance.

The steam enters the space G through the regulating valve R, expands against the screen E', traverses the annular space S, comes in contact with the distributors that turn it in a centripetal direction against the other receptacles. From one turbine it passes on to the next, and is thus gradually expanded.

Centrifugal Turbine (1891, fig. 2).—In this type the steam is admitted into the space F. The turbines B keyed upon the shaft A touch each other, and are so designed that their diam-

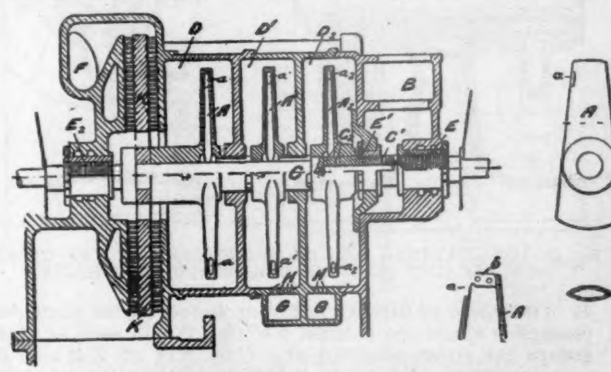


Fig. 4.—Details of Parsons' Reacting Turbine.

eters decrease as we move from the exhaust end. The steam, after having successively passed through the different fixed directors and the first crown O and the wings of the movable disk B, passes from the last circle of B to the first circle of the directors c, and so on, successively expanding, until it escapes into the air or the condenser at a low pressure.

The exhaust G is in communication with the outside face of the piston E. This piston is provided with circular ribs that enter corresponding grooves in the cylinder F, and is so calculated as to almost equalize the thrust of the steam, which tends to separate the disks B from the crowns C. In the last instance the inventor has produced a motor (figs. 3 and 4) which reminds one of the eolipyle of Heron.

The steam (fig. 3) admitted to B enters the first arm A_2 through the holes C^1 and C^2, whence it escapes through the tangential openings a a into the first chamber D_2; thence it passes from this chamber by the annular opening cut around the shaft C into the second arm A_1, and so on to the last chamber D, whence it escapes through F either directly or after having exhausted its force on the turbine K (fig. 4). Leakages

of steam around the shaft C are avoided by the grooves $E\ E_2$, and the water of condensation from the chambers $D_1\ D_2$, which accumulates in the pockets G through the holes H. The steam

close the openings i and open i'. A greater amount of steam will then pass through this side of the system, and thus draw it back into its normal position. It is a centrifugal turbine.

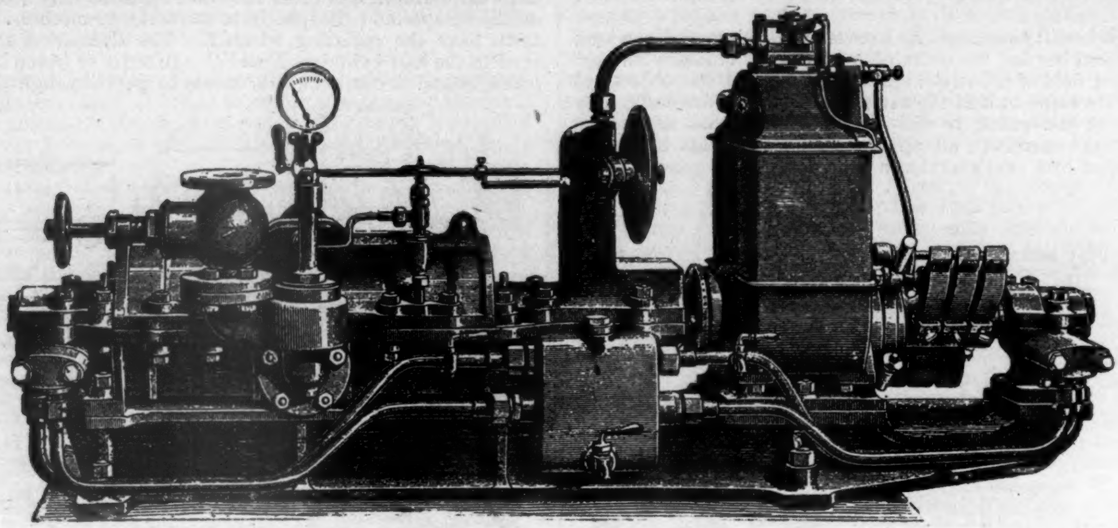


FIG. 5.—PARSONS' TURBINE ELECTRIC GENERATOR.

thus expands from the arm A to the next, and through the successive chambers $D\ D_1$. . . .

Fig. 5 represents a Parsons turbo-electric generator.

DUMOULIN TURBINE (1886).

In figs. 6 and 7 the casing B is keyed to the shaft O, which turns around the disk indicated by double-hatched lines in fig.

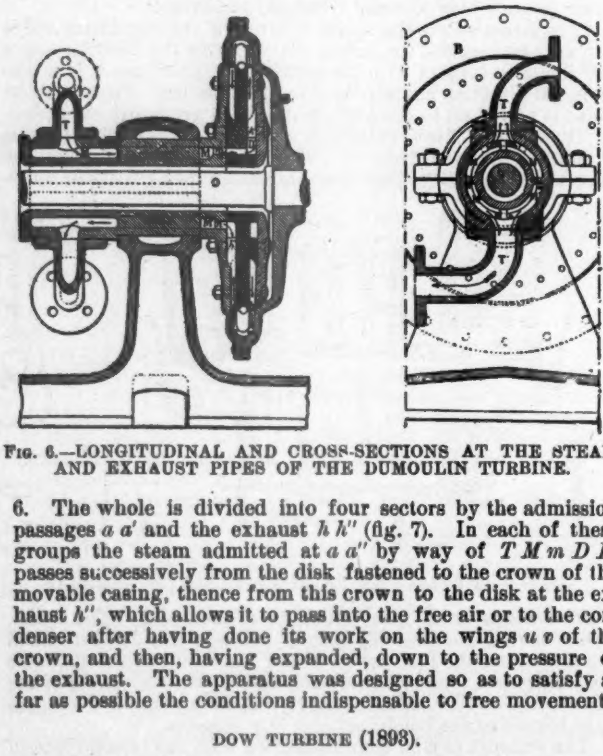


FIG. 6.—LONGITUDINAL AND CROSS-SECTIONS AT THE STEAM AND EXHAUST PIPES OF THE DUMOULIN TURBINE.

6. The whole is divided into four sectors by the admission passages $a\ a'$ and the exhaust $h\ h''$ (fig. 7). In each of these groups the steam admitted at $a\ a''$ by way of $T\ M\ m\ D\ D'$ passes successively from the disk fastened to the crown of the movable casing, thence from this crown to the disk at the exhaust h'', which allows it to pass into the free air or to the condenser after having done its work on the wings $u\ v$ of the crown, and then, having expanded, down to the pressure of the exhaust. The apparatus was designed so as to satisfy as far as possible the conditions indispensable to free movement.

DOW TURBINE (1893).

In figs. 8 and 9 the steam which is admitted at A passes through the openings C_1 in the washers C, and the clearance spaces $i\ i'$ allowed between the faces of these washers and that of the disk F, which is keyed upon the shaft D, enters the wings of the first pair of wheels $E\ E$ and the corresponding directrices of the disks $c\ c_1$ to escape radially into the chamber L, whence it passes to a second pair of receivers, $A^1\ E$, thence to a third, $A^2\ E$, whence the steam finally escapes at M under a very low pressure. The outline of the directors $c\ c'$ and the wings $e\ e'$ is clearly shown in fig. 9. The pressure on the right and the left of the disk F is always equal, for, if the effort to the right is the greater, all of the receptacles move in this direction, and the disk F, striking against the washer C, will

EDWARDS' TURBINE (1892).

This turbine, which is shown in figs. 10 and 11, is composed of a movable disk, 30, between two fixed plates 14 and 15, and turning the shaft by means of the plate 31. Steam is admitted at 10, 11, 12 and 21, between the movable disk and the two fixed disks, and escapes through 33 after having expand-

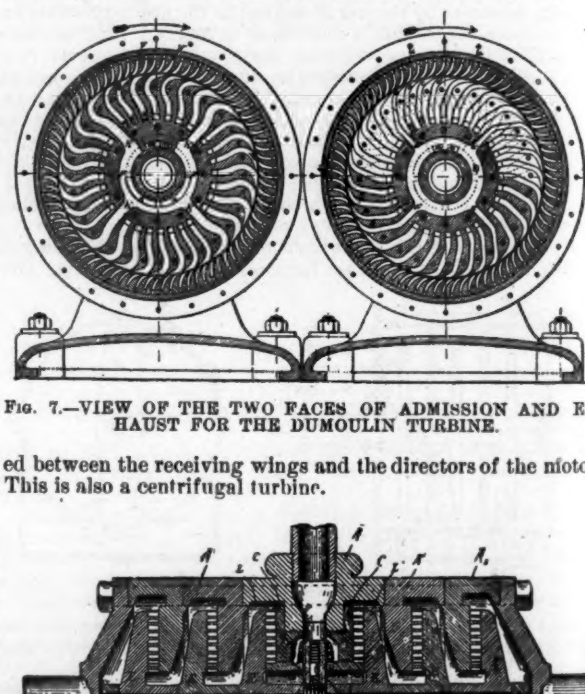


FIG. 7.—VIEW OF THE TWO FACES OF ADMISSION AND EXHAUST FOR THE DUMOULIN TURBINE.

ed between the receiving wings and the directors of the motor. This is also a centrifugal turbine.

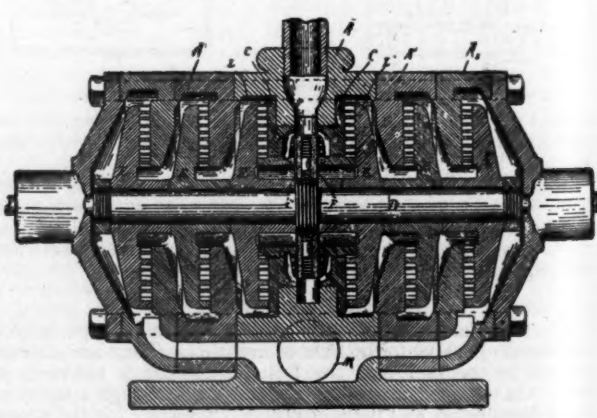


FIG. 8.—LONGITUDINAL SECTION OF THE DOW TURBINE.

The play between the motor disk and the plates is about three one thousandths of an inch, and it can be adjusted with great precision by the vernier 40 (fig. 11) that is cut upon the plates 14 and 15.

McELROY TURBINE (1893).

In this turbine (fig. 12) the steam follows a centripetal course. Admitted at $J\ H$ around the motor disk A, it escapes from the centre at G through $g\ g$, after having run through the spiroidal passages K in the plates F, which are enlarged

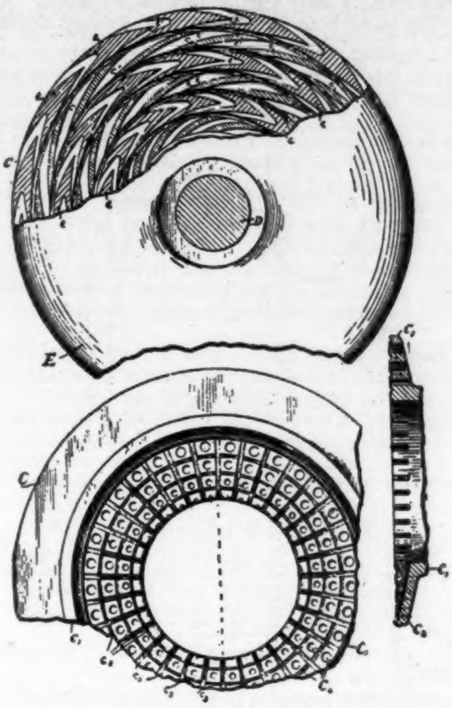


FIG. 9.—CROSS-SECTION OF THE DOW TURBINE.

toward the centre so as to allow the steam to expand at the same time that it acts upon the wings of the disk A.

SEGER TURBINE (1893).

This turbine (fig. 13) consists of two wheels, a and b, joined by pinions so as to turn at the same speed, but in opposite directions. They are enclosed in a chamber whence the steam

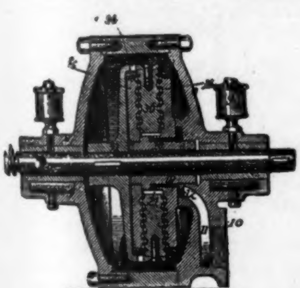


FIG. 10.—LONGITUDINAL SECTION OF THE EDWARDS' TURBINE.

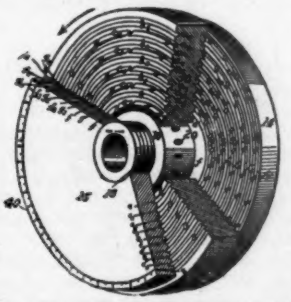


FIG. 11.—DETAILS OF THE DISKS OF THE EDWARDS' TURBINE.

escapes after having passed from c into a and b through the wings of these two wheels, which receive it. We merely mention this turbine, which never seems to have seen the light of day, and whose efficiency was only very moderate.

As will have been remarked, all of these machines utilize the pressure of the steam while working in tight compartments and turning at high velocities. The play of three one-thousandths of an inch can be obtained, but it will be difficult to maintain it under working conditions, so that the leakage will grow greater and greater and the utilization of the pressure of the steam will become more and more defective.

(TO BE CONTINUED.)

MACHINE DRIVING WITH ELECTRIC MOTORS.

IN a paper read before the American Institute of Electrical Engineers at Niagara Falls, by Messrs. F. B. Crocker, V. M. Benedikt, and A. F. Ormsbee, after instancing several cases where electric motors have been successfully introduced for the driving of machines, they sum up with the following conclusions :

First Cost.—Practically the only objection which can be urged against the electric system is the fact that the first cost of installation is greater than with ordinary belting and shafting, but even this is questionable, since the authors know of cases in which the estimated total cost of installing the necessary belting and shafting was actually greater than the equivalent electric motor outfit. The electric system would be

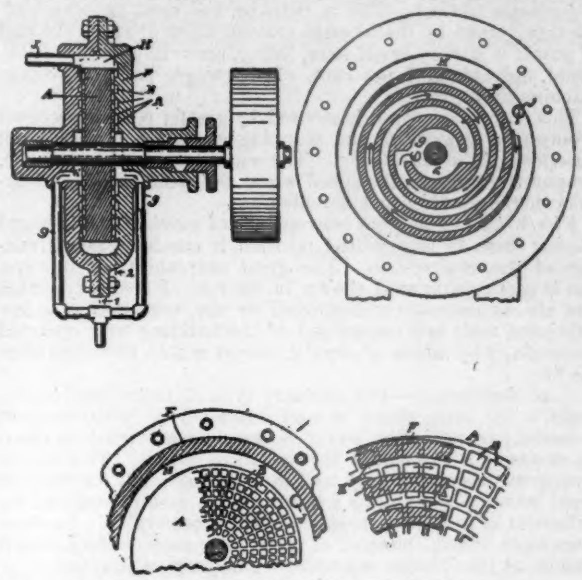


FIG. 12.—DETAILS OF THE MACELROY TURBINE.

cheaper, for example, in the case of very long or scattered buildings or those containing many stories or rooms, in any of which cases the belting and shafting required would be very complicated and expensive. The use of belting and shafting requires a much stronger and more expensive roof or ceiling than the electric system.

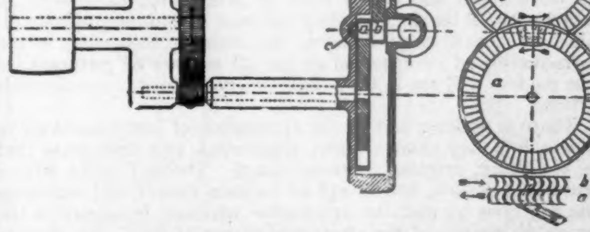


FIG. 13.—DETAILS OF THE SEGER TURBINE.

Saving of Power.—It might seem that the electric system would actually consume more power than the ordinary plan, since it involves two transformations of energy. In most cases, however, if the power has to be distributed to a number of machines, particularly if they are located at any distance from the engine, the loss of power is less with electric transmission. This is explained by the high efficiency of the dynamo and motor compared with the low efficiency of belt transmission as ordinarily practised, involving as it often does very imperfect alignment and lubrication of the shafting. Perhaps the greatest saving, however, of the electric system is due to the fact that the consumption of energy entirely ceases when the tool stops. This stoppage in the case of the busiest tools amounts to at least 25 per cent. of the nominal working hours throughout the year, and with large or special tools which are not used so steadily the stoppage is often as high as 50 to 75 per cent., since there are many whole days when they are not used at all.

Idleness due to strikes as well as to slack times must also be considered, and would usually amount to quite a large percentage in ten years, for example. This assumes, of course,

that a portion of the shop is running, which is usually the case even under such conditions. In short, with the mechanical system there is an enormous amount of shafting, idle pulleys, and belting which runs for long periods of time doing little or no useful work, but consuming considerable power.

Wherever electric motors can be substituted for a number of small engines scattered about, the saving in power is very great, not only because of the low efficiency of small steam-engines, but also by the avoidance of condensation in long steam-pipes.

Increased Output.—This is, perhaps, the most important advantage gained by the electric system, since after all the cost of power is a very small item, being, according to Mr. Richmond, only about 1 per cent. of the wages paid in average machine-shop practice.

This increased output is secured by greater convenience and promptness in starting and stopping as well as in regulating the speed of the machinery. The workman can, for example, temporarily increase the speed when the conditions are favorable, thereby saving considerable time.

Flexibility.—The great convenience of moving the tools and placing them in any desired position is another great advantage of the new system. The great adaptability of this system is particularly well shown in the case of a factory which was almost completely destroyed by fire, nevertheless a few uninjured tools in a remote end of the building were operated successfully by means of electric motors within two days after the fire.

Speed Regulation.—The ordinary type of motor used in factories is the plain shunt wound machine fed with constant potential current. The motor is started and varied in speed by means of a rheostat in the armature circuit. This simple arrangement answers very well in most cases, but for variable speed between wide limits a series wound motor controlled by a rheostat as in railway practice may be preferable. In other cases some special method of regulation, such as the Leonard system, or the "boost and retard" plan may be adopted.

AMONG THE SHOPS.

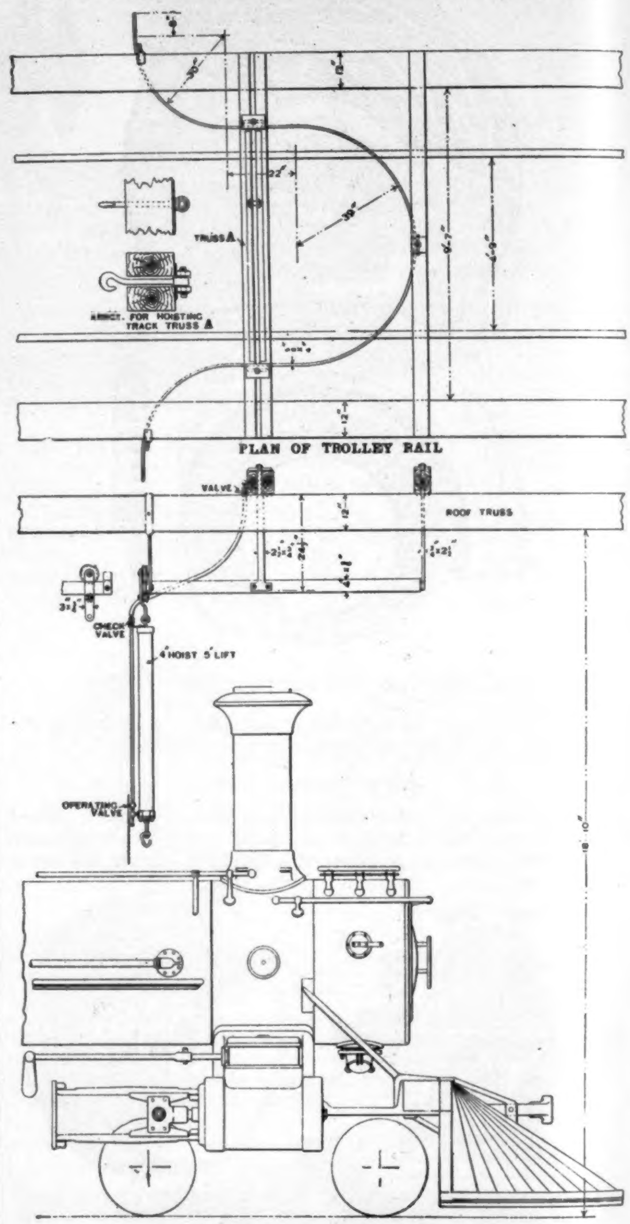
WEST PHILADELPHIA.

They say that the hard times of the past two years have had a tendency to develop the latent inventive talents of the master mechanics in charge of the shops of the railroads of the country, in that their allowance for expenses have been cut down, while the amount of work required has by no means fallen off in anything like proportion to the cutting down of the said allowance. Whether this be true or not of the West Philadelphia shops of the Pennsylvania Railroad, it certainly is a fact that they have some mighty interesting little wrinkles at work there, and which have so established themselves in favor with all hands, that they are now considered indispensable. Of course they are up to the times in the matter of the introduction of compressed air for all manner of purposes, as our readers will see if they take the pains to go through this article.

There is nothing new in the application of compressed air to hoists, but they have a novel application to a drill press that is, we think, original in these shops. Drilling holes with a hand feed is slow, and is apt to become slower and slower as the day goes by and the apprentice becomes interested in the probable results of the afternoon's game of ball. To obviate such loss of time, the table of a small drill has been fitted with a plunger that fits into a cylinder that is, in turn, connected with the compressed-air pipes. The piece to be drilled is placed on the table, the air is turned on, the table rises with a constant and continuous pressure and forces the metal against the drill. The feed or pressure is proportioned to the capacity of the drill to cut, and the work is done in the shortest possible time, regardless of the fact as to whether the pitcher of the home team is in good form or not.

At the track where wheels are removed from and put under the engines there are two heavy jacks used for raising the locomotives. The heads of these jacks are fitted to receive the cross-bar upon which the engine rests, and the whole is of such a weight that the adjustment takes more time than should be consumed in doing the work. To save time at this point, an overhead track has been put up, and from a couple of trolleys running on them there hang two rods fitted with turnbuckles by which the jacks can be lifted from the floor and run along the side of the engine to the point where it is desired to use them. Then, in order to avoid the heavy straining and delays incident to lining the wheels and getting them upon the track over which the engine is standing, there is a ram in the floor just beyond the end of the engine which is used to lift the wheels from the floor while they are swung around into line. This ram is operated by compressed air.

Every man who has had to do with locomotive repairing has been troubled to a greater or less extent by the inadequacy of the means of handling the heavy parts that must be removed even in cases where only partial repairs are made. At West Philadelphia there is an air hoist rigged around the front end



AIR HOIST FOR LOCOMOTIVE PITS.

of every pit in the repair shop. The form of this track is clearly shown in the engraving, and it will be seen that with the hoist travelling over this track everything on and about the front end of the locomotive can be lifted and lowered to the floor, thus doing away with the necessity for a large gang of laborers, whose sole duty is to tire themselves and every one else with their heavy lifting. In order to handle the other parts that are located further back and out of reach of this hoist, such as the dome caps, air pumps, etc., there is another track that is pivoted over the back end of the cab, and which itself travels on a trolley running on a circular track just back of the stack. On this track there is a chain hoist that can be made to cover all of the back end of the engine; and, after the part to be removed is swung free, it is run forward and brought out far enough to clear the engine and lowered to the floor. Thus the man doing the work, with the assistance of a single helper, can take down any part of an engine and replace it, and that, too, without any very great exertion, and certainly without making a fuss about it.

The same idea has been carried out in the blacksmith shop, where the heavy forms for the steam hammers are kept on a floor outside of the building. An overhead track runs from the two hammers, where a variety of forms are used out through the door where there is a switch, and turning passes over the place where the forms are kept. On this track there is an air hoist which can be made to pick up the form and carry it to the hammer and put it in place without the men doing the work being compelled to do any lifting at all. The objection to the use of air where the hoist is to be moved for any distance that an inconvenient length of hose must be used is overcome in this instance by having an air connection at each of the hammers and a length of stationary hose at each of the storage places sufficient to reach the hoist wherever it may be standing, and then equipping the latter with an air-brake coupling, which permits the connection to be made and the load lifted. Then the connection is broken and the load carried to the point where it is to be lowered, and a new connection made to do the proper adjusting. This certainly solves the problem where the load is always handled at given points within the range of lengths of hose of moderate lengths.

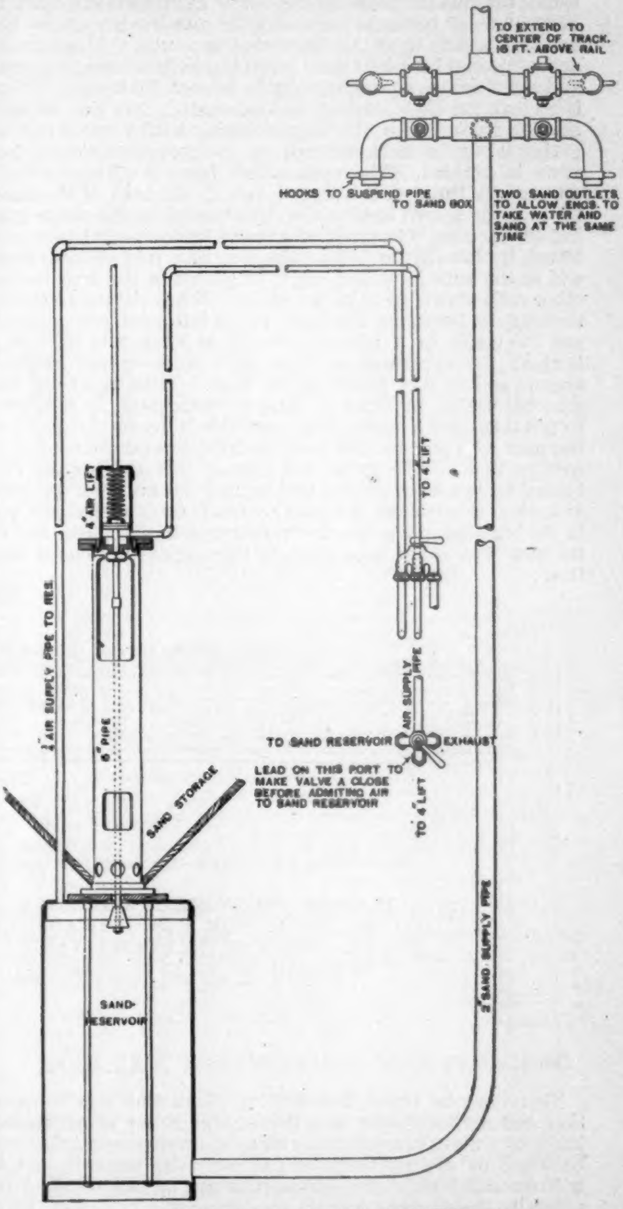
Before leaving the blacksmith shop we wish to call attention to a wrinkle that saves lots of trouble and more expense. Here there are two special forges that are used for doing overtime work, and which are fitted to be blown by compressed air taken from the pipes that supply the shops and the hoists. As this air is drawn from the mains that supply the air for the signals in the Philadelphia yard, it is always present; and no matter when there is a call for overtime work, these forges are ready. In ordinary working they use the air from the blower the same as the other fires in the room, as this is cheaper than the compressed air; but the latter comes at the lower price when a single fire is wanted, and it would be necessary to run the whole shop in order to keep the blower in motion.

To those who are familiar with the shot-gun feed that is used in the saw-mills of the Northwest for moving the carriages of circular saws, a handy adaptation of the same will be found in these shops. There is an air hoist travelling on an overhead track for swinging driving-wheels into the lathe. As pushing them by hand is more or less difficult, and is always accompanied by a certain amount of swinging, a long cylinder is bolted to the ceiling, and in this there is a piston and rod, the outer end of the latter taking hold of the trolley carrying the hoist. Thus, by admitting compressed air to one side or the other of the piston, it is moved in or out and the load conveyed to the point desired. It is so simple that it would not attract attention but for the extreme handiness of the device. This long cylinder has, of course, a piston stroke equal to the total travel of the trolley.

As the Light Brigade are said to have found cannon on all sides of them, so in the West Philadelphia shops compressed air seems to be used for every conceivable purpose. One of these appliances is shown by the engraving, where it is represented as lifting the dry sand for the locomotive's from the bin to the sand-box on the boiler. It is automatic in its action other than the necessary handling of the three-way cock that is outside of the building. Beneath the bin for the storage of the sand there is a cylindrical vessel called the sand reservoir. When not in use, the valve shown at the top of this reservoir is down and open, as in the engraving. The pipe which rises from the top of the reservoir has holes cut in the shell, as shown, and through these holes the sand flows down into the reservoir until the latter is filled, and this is enough to fill a sand-box on an engine. When an engine is to be sanded, the handle of the three-way cock is turned, and as it is moved it first, by reason of the lead that is given to the valve, admits air into the pipe leading to the 4-in. lift. The result of this is that the piston in this lift or cylinder is forced up, thus closing the valve at the top of the sand reservoir. As the handle moves further, it opens and admits air into the ¾-in. supply pipe to the reservoir. Then, when the valves at *X X* are opened, the compressed air rushes out and carries the sand with it, the latter falling into the sand-box on the locomotive, whose opening is directly underneath. As soon as the box is filled the valves at *X X* are closed and the three-way cock also, when the valve at the top of the reservoir drops into the position shown, and the sand again flows down to take the place of that which has been removed.

It is barely possible that Diogenes was mistaken in the honest man that, after a long search, he finally decided he had discovered, and so it may be that we are mistaken in thinking that we have found the best method of flue welding that exists. We have been looking for a long time for a flue-welding plant that we could recommend in all of its particulars, but there has always been some drawback in the tools used or in their arrangement that left the plant open to criticism. Either something would be wanting, or the flues would need more handling than a specification for an ideal system would permit, or they would not travel in a direct course from start to finish, or there would be an obstruction in the way. At any rate, we have not seen what we were looking for until that in use in the West Philadelphia shops was happened upon.

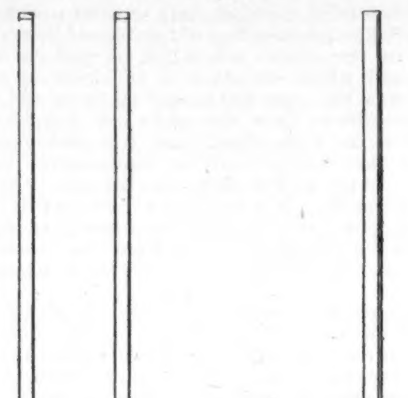
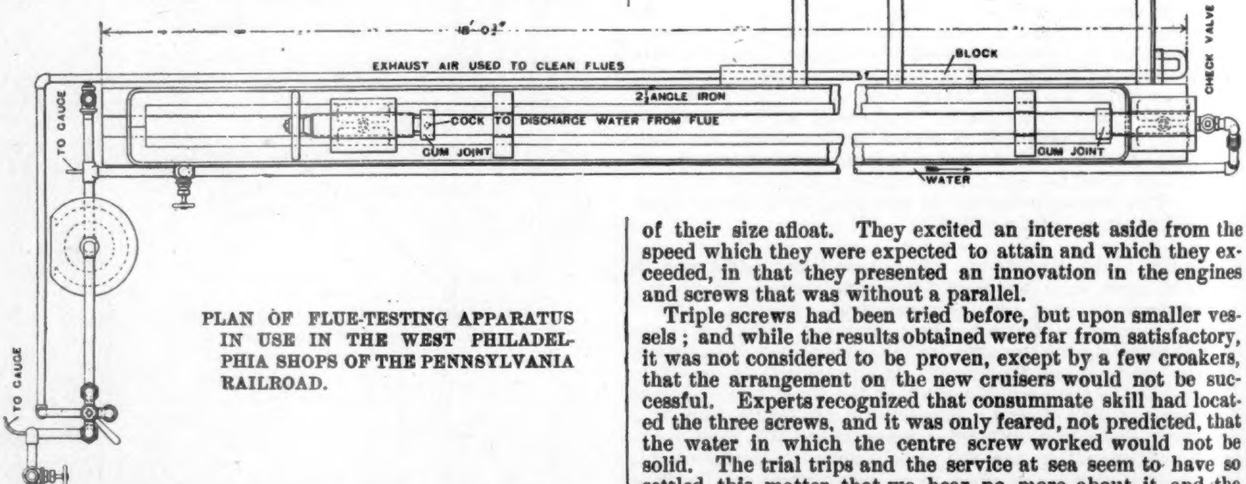
One side of a small shop is devoted to this work. At one end there is the rattler, boxed and protected so that no dust escapes into the shop, and the noise that is heard is reduced to



COMPRESSED AIR SAND-LIFTER.

a minimum. Immediately at the side of the rattler is the lathe where the tubes are cut and scarfed. Here there is a little wrinkle in the shape of a conical bearing that holds the tube central while the scarfing is being done, and prevents any uneven work on the part of the tool. Just beyond this lathe there is the forge for welding, so that the handiest place for the scarfer to put the tubes is also the handiest place from which the welder can pick them up to place them in the fire. Beside the forge there is a welding machine very if not exactly similar to the beading machine illustrated in our issue for May of this year. One step, therefore, takes the smith from the forge to the welder, and the tube is again dropped in the handiest place for the man whose work upon it is finished. This happens to be an incline like the log incline of a saw-mill, and leads down to the testing apparatus shown in the accompanying engraving.

In some respects this is like all of the other flue testers that are in use in the hundreds of shops in the country, except that it goes a step farther than any of them, and is neater, handier and more efficient than any other that we have seen. As Beau Brummel said of the wonderful cravat that is reported to have cost the prince so many sleepless nights, "Starch is the man." So here we can say, "Compressed air is the man." The tube is put in the machine and the ends tightened in the same way that it is done in the machines with which all are familiar; water from the city mains is turned on until the tube is filled and all of the air is out. Then air is turned on, and, entering the top of the larger cylinder shown in the end elevation, forces the smaller piston in the lower cylinder down upon the body of water beneath, increasing the pressure per square inch, and thus acting upon the interior of the tube. All of the disagreeable and laborious hand pumping is thus done away with, and the man has an opportunity to inspect the work. If there is no leak the air is shut off and exhausted, and here comes in the fine work. The old way of lifting a tube up on end and giving it one or more thumps on the ground to clear it from scale is avoided. The exhaust air from the upper cylinder passes out through the pipe shown at the back of the tester, through the return bend at the right-hand side, and as the opening of this pipe is in exact alignment with the next tube to be tested, it blows through this tube and clears it of all loose scale; and as the tube is picked up to be placed in the machine, another rolls down to take its place. When the tube has been thoroughly inspected the cock at the left-hand end is opened and the water in it allowed to run to waste into the trough beneath the apparatus, so that there is never any slopping around and no wet places on the floor. Then, when the man who has tested the flues is through with them, he is allowed to put them down behind him; and this is the very place where the man who puts on the ferrules finds it most convenient to receive them. The tubes are ground and the ferrules then brazed on in a separate fire that is used for no other purpose, and when this is done the tubes are stacked up against the wall in the handiest place for the ferrule man to put them, and for the men who are to take them to the engines to remove them from.

PLAN OF FLUE-TESTING APPARATUS IN USE IN THE WEST PHILADELPHIA SHOPS OF THE PENNSYLVANIA RAILROAD.

There may be better flue-welding plants than this in operation, but we have never seen them; still, if any of our readers know of a more convenient or efficient arrangement, they will be doing us a great favor to call our attention to it, and we will do our best to give this superlative apparatus all of the publicity that it deserves.

THE UNITED STATES CRUISERS "COLUMBIA" AND "MINNEAPOLIS."

In previous issues* of this journal we have published very complete descriptions of the hull and machinery of the two United States armored cruisers, the *Columbia* and the *Minneapolis*. At the time of the publication of the accounts of these vessels they were in course of construction, and the only illustrations available were those taken from the drawings of the Navy Department. Now, however, that the vessels are in commission, photographs of them have been taken, two of which we reproduce on pages 412 and 413. It will be seen, on comparing that of the *Columbia* with the one published in our issue for October, 1890, that the design has been slightly modified by a rearrangement of the boilers, whereby the vessel has four smokestacks instead of three. The *Minneapolis* is a sister ship to the *Columbia*, but a further rearrangement of boilers put two stacks upon her. With the exception of these slight modifications in detail the vessels are the same in structure, armament, engines and boilers.

Probably no two vessels have ever been added to any navy that have attracted more attention than these. While they were still officially known as cruisers Nos. 12 and 13, they were nicknamed the "Pirates," because of their avowed purpose of being able to fill in the navy of the United States the place occupied by the *Alabama* in the navy of the Confederacy. They were built to be commerce destroyers, and with their guaranteed speed of 21 knots, which became 23.07 knots on the official trial of the *Minneapolis*, and 22.8 knots in the case of the *Columbia*, it was acknowledged by experts upon both sides of the Atlantic that they could overhaul and destroy any vessel of their size afloat. They excited an interest aside from the speed which they were expected to attain and which they exceeded, in that they presented an innovation in the engines and screws that was without a parallel.

Triple screws had been tried before, but upon smaller vessels; and while the results obtained were far from satisfactory, it was not considered to be proven, except by a few croakers, that the arrangement on the new cruisers would not be successful. Experts recognized that consummate skill had located the three screws, and it was only feared, not predicted, that the water in which the centre screw worked would not be solid. The trial trips and the service at sea seem to have so settled this matter that we hear no more about it, and the triple screw is acknowledged to be a success. Indeed, any other conclusion would be impossible to reach when we note the gain of 11.9 per cent. in the economy of propulsion of the triple screws over the twin screws as compared with the cruiser *New York*.

It is needless to recapitulate the details of the vessels, which are very fully given in the issues to which we have already referred; but it will be interesting to note one of the recent performances of the *Columbia*.

It must be remembered that these cruisers are not intended to fight heavily armored battleships, but to catch and cripple the fast vessels of an enemy's mercantile marine. They are, therefore, built with a large coal capacity, and are engined so as to be economical in the use of fuel at all rates of steaming.

The total coal capacity is very large, reaching 2,000 tons; at 10 knots speed per hour this will give the vessel an endurance of 50 days, or a radius of action of 12,000 nautical miles, or sufficient to go half around the world.

We cannot do better than quote the remarks of Mr. Biles, at the time of the launching of the *Columbia*, regarding the special mission of these sister ships to overtake and destroy: "The commerce destroyer is about the same length as the 17 and 18-knot merchant mail steamers, and no doubt could very easily overhaul any vessel of her own length in almost any

* American Engineer and Railroad Journal, October, 1890; December, 1890; September, 1892; September, 1893, and December, 1894.

weather ; but even though she may have a sustained sea speed in moderate weather of 21 knots, it is very doubtful whether, in average Atlantic weather, she could catch such vessels as the *Teutonic* and *City of Paris*, for their extra length is considerably over 100 ft., and their extra weight, which would be nearly double, would inevitably tell in a seaway. It is further doubtful whether the bow of this vessel above water is, either in shape or height, well adapted for driving against a head sea at such a high speed. Her freeboard forward is 19½ ft., which is low as compared with the *City of Paris*—32 ft. It is not very apparent what is gained by having a long projecting underwater stem in such a vessel. To use it would be to cripple herself in the quality for which everything has been sacrificed—namely, speed. A straight stem, like most merchant ships have, but with considerable flare out, would probably improve her speed in a head sea, and would certainly keep her drier forward. For continuous steaming at high speeds the well-tried mail steamer would be more efficient. It would be quite easy to arrange in the design of mail steamers intended to act as commerce destroyers that structural framing, shaped and situated like a protective deck, should be fitted, on which in time of war thick plates could be laid and secured."

Whether or no there has been any driving of the *Columbia* against a head sea, whereby the strictures of Mr. Biles regarding the low freeboard forward have been disproved or substantiated, we have been unable to learn, but the probability is that no such trial has ever been made. The only attempt that has been made to drive the vessel at a high speed for a long distance occurred on a recent voyage from Southampton, England, to New York, when the ship was returning from the Kiel festivities incident to the opening of the Baltic and North Sea Canal.

The record of this voyage is briefly as follows :

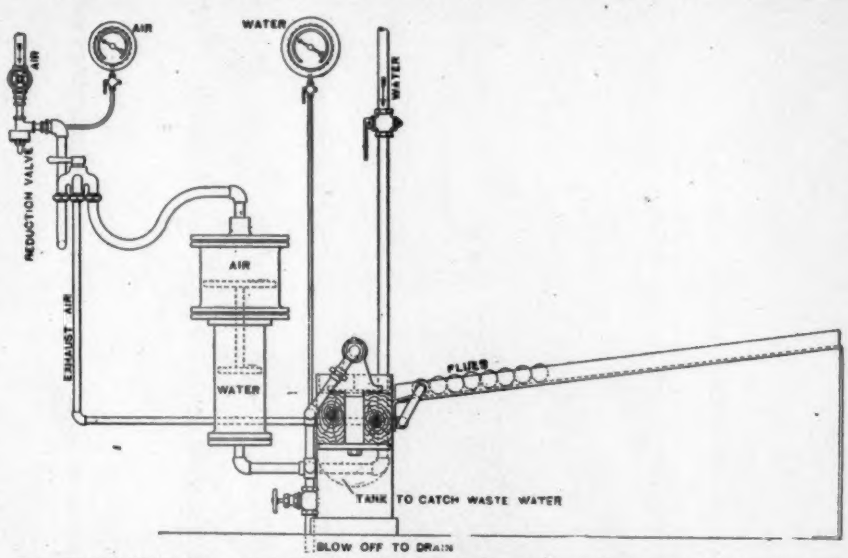
The *Columbia* left Southampton on July 26, having on board 1,973 tons of coal, filling the bunkers and utilizing the wing passages and fire rooms, and even the decks, where 40 tons were stowed away under the superstructure. With this load the vessel drew 26 ft. 4 in. forward and 25 ft. 7 in. aft—an unfortunate trim, but unavoidable. The fire-room force was 12 short, and that number was made up by volunteers from the deck force, and three petty officers were transferred to the engineers' department to assist in carrying coal. It was intended to speed the vessel under forced draft for the last 24 hours of the voyage, but this was abandoned as impracticable, for while there were 300 tons of coal left, it was at the ends, and could not be moved sufficiently fast to feed the fires for such a test. The coal was the best obtainable at Southampton, and of the quality used by the American Line.

Under these conditions the *Columbia* passed the Needles at two P.M. on July 26, and made the run to Sandy Hook Lightship in six days, 23 hours, and 49 minutes, covering 3,112 nautical miles at an average speed of 18.53 knots an hour, and placing to her credit, we believe, the best long-distance run ever made by a warship. The schedule of her daily runs, as taken from the ship's log at noon of each day, is : 405, 487, 470, 457, 455, 453, and 405, the last being taken upon her arrival at the Sandy Hook Lightship at eight o'clock on the morning of August 2.

An interesting comparison may be made with the run of the *Augusta Victoria*, of the Hamburg-American Line, which came over at the same time, arriving at the Lightship two and one-half hours behind the *Columbia*. The distance covered by this vessel was 3,054 nautical miles, and it was traversed in six days, 20 hours and 20 minutes, the average speed being 18 54 knots, or .01 knot faster than the *Columbia*. Thus it appears that the cruiser can be driven at the same speed as that at which an express passenger steamer is run on an ordinary passage, but that .01 knot is sufficient to give safety to the latter in the case of a stern chase. Undoubtedly the *Columbia*, with her forced draft, could do decidedly better than the 18 53 knots of the present record ; and it is claimed by some of the engineers of the Navy that the *Minneapolis* can do still better ; but this remains to be seen. As for the coal consumption, a test was made with the *Columbia* some time ago, in which, on a six-hour test, the following results were obtained :

No. of Screws Used.	Speed in Knots.	Coal Burned Per Day.
3	16.41	125.6 tons.
1	10.06	38.3 "
3	18.04	223.0 "
2	13.36	70.2 "

As far as the investigations have been carried it may be considered that these pirates, or commerce destroyers, or cruisers have fully met the expectations and intentions of their designers. It has been shown that for a burst of speed they can run at a rate faster than that of any transatlantic liner ; that they are capable of a maintained sea speed for a long voyage up to the average rate of the express mail steamers, and that in the economical consumption of coal for power developed and speed produced they are the equals of any vessels afloat both in engine and boiler capacity. With these points thoroughly proven, it does not seem unreasonable to conclude that the one remaining feature—ability to stand hard driving through a heavy head sea—will also be found possible. While the criticisms on this point are made by men of undoubted ability and world-wide reputation, it will be noticed that they are not made in the form of positive assertions and predictions, but rather as a surmise, just as it was feared that the central screw would not have solid water in which to work. Still it is a point worthy of attention, and an actual trial would be worth more than all the surmises and opinions that could be expressed till the end of the next century.

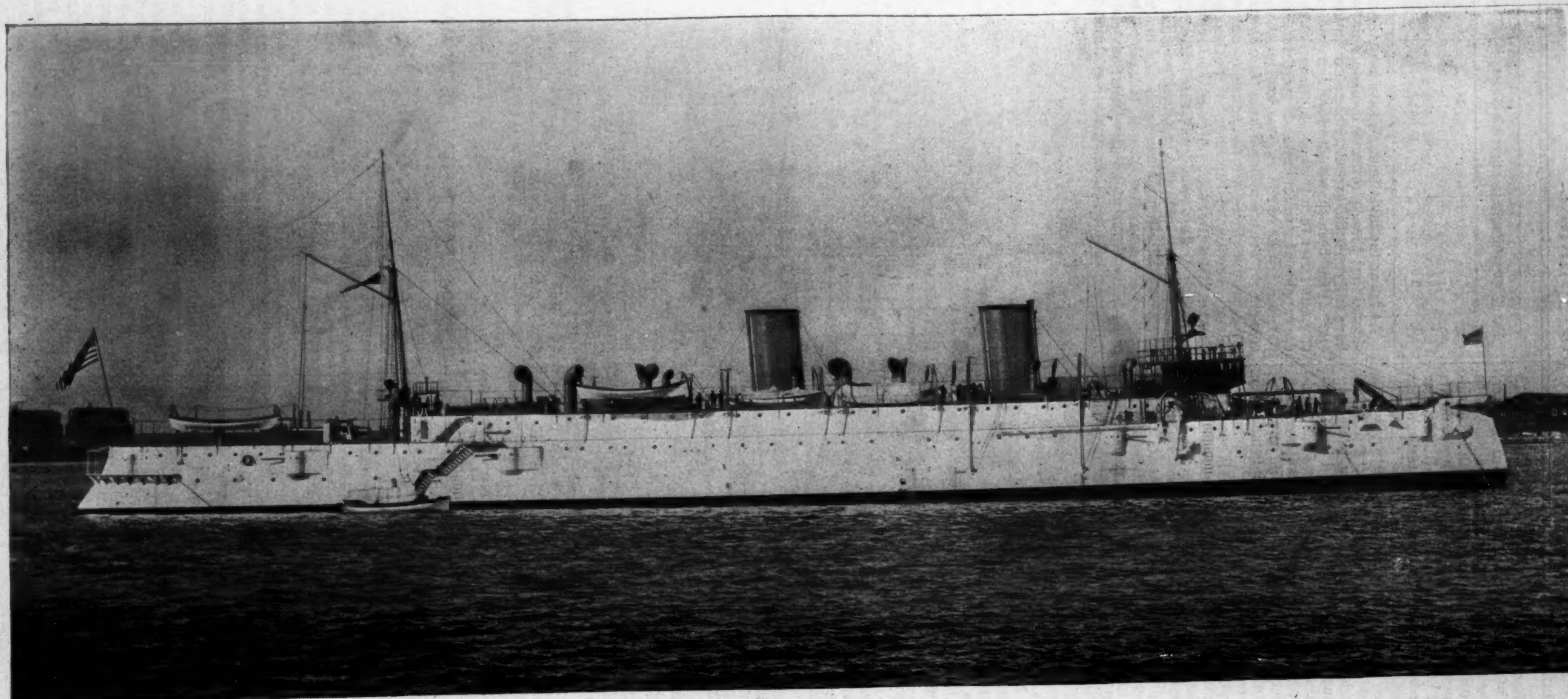


END ELEVATION OF COMPRESSED AIR AND WATER-PRESSURE ARRANGEMENTS OF FLUE-TESTING MACHINE AT WEST PHILADELPHIA.

ELECTRIC RAILWAYS IN MARYLAND.

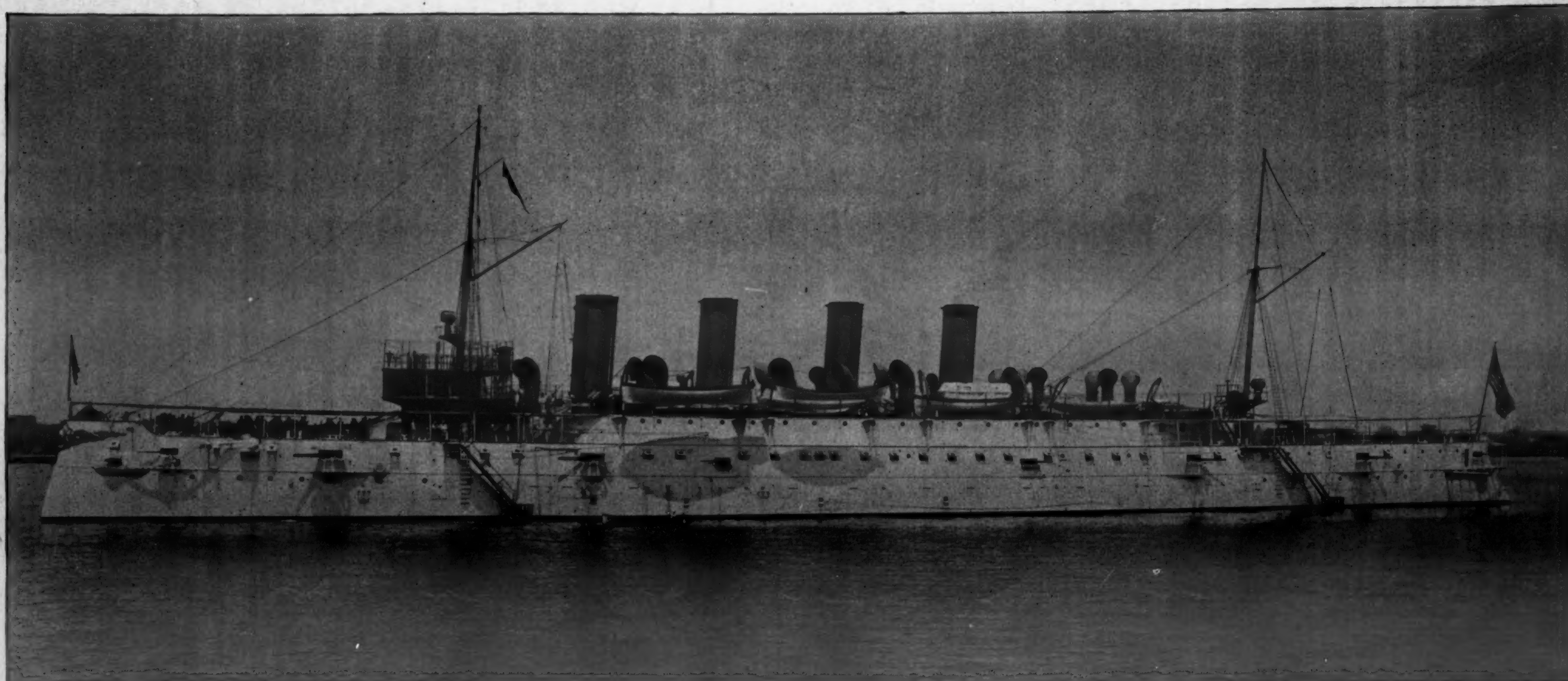
The idea of utilizing electricity to supply means for local transportation has taken a strong hold upon the people of Maryland. In many parts of the State farmers, fruit-growers and quarrymen are remote from the railroads, and are practically without facilities for sending produce quickly to the market. Within a brief period these people have seen the city of Baltimore leap suddenly forward a quarter of a century through the agency of rapid transit. Before their astonished gaze the problem of connecting the business centre with the distant suburbs has been worked out, whereby the value of property is enhanced and the circle of possible residence for city people vastly widened. They have seen popular resorts spring up 10 miles from the city, inviting crowds daily to the enjoyment of cool breezes and delightful shade. Moreover, this spectacle has created a profound impression upon practical men in the counties, and they have begun to ask why electric railroads running along the turnpikes should not do for rural communities what they have done for the territory immediately surrounding Baltimore.

The evolution of electric railroads in Maryland exhibits three successive stages, two of which have been passed. After a few unsuccessful experiments with electricity as a motive



Photographed and Copyrighted by W. H. Rau, Philadelphia, Pa.

THE UNITED STATES CRUISER "MINNEAPOLIS."



Photographed and Copyrighted by W. H. Rau, Philadelphia, Pa.

THE UNITED STATES CRUISER "COLUMBIA."

power for street cars, its use was abandoned, and the first lines to introduce rapid transit employed the cable motor. But the expense of construction soon put an end to that, and the several-street-car companies in Baltimore took up the trolley system and set about making the necessary changes to put it into use. Within three years all the old horse-car lines have been fitted out with the new appliances, requiring 275 miles of track to be replaced, and calling for an expenditure of $10,000,000 in the way of improvements. This constituted the first stage.

The second step was to expand these city systems by building roads into the suburbs. With a single exception, the corporations owning street railways in the city have extended their tracks greater or less distances into the adjoining counties. Lines are now in operation to Curtis Bay, across the Patapsco River; to Catonsville, 6 miles southwest of the city; to Powhatan and Gwynn Oak Park, forming an extension loop nearly 10 miles in the circuit; to Pikesville and Arlington, each 7 miles from Baltimore; to Lakeside Park; to Towson, the county-seat of Baltimore County; to Highlandtown and Point Breeze, 3 miles down the river; while a company has been formed to build a trolley line to Mt. Washington, 12 miles from the City Hall, and the road-bed is being graded for the new line to Ellicott City, which will be 11 miles in length. These suburban roads are legitimate extensions of the city systems, and are operated by the same companies. They have been built to satisfy the demands of local traffic, and the success of the experiment may be judged from the results achieved on the Pikesville branch of the Traction Company. This line starts near Druid Hill Park, in Northwest Baltimore, and follows the turnpike to Pimlico and thence by separate tracks to Pikesville and West Arlington, the road deriving its patronage largely from the people who go daily to the racing grounds at Pimlico and Arlington. The property is capitalized at $500,000, earning 6 per cent. on that amount, and it may be taken as a fair illustration of the income received on other suburban lines.

The third stage in the development of electric railroads in Maryland is yet in its beginning. Thousands of people annually attend the gatherings at Emory Grove and Glyndon, points about 20 miles from Baltimore. The Western Maryland Railroad passes in front of both camp grounds, and has been hitherto the chief source of communication between them and the city. But a company was formed last year, independent of the city railway corporations, to build a trolley road from Pikesville to Reisterstown, with a branch running up to Emory Grove. This line was opened to traffic in the month of May, the fare being 50 cents for the round trip, or $1\frac{1}{10}$ cents a mile. The road is practically an extension of the Pikesville branch of the Traction Company's system, except that it is owned and operated by a separate company, passengers being obliged to transfer from one line to the other on the platform in Pikesville. However, by a traffic arrangement between the two companies it is possible to purchase tickets from conductors on any of the Traction Company's lines in the city and ride to Emory Grove by making the necessary transfers. By this means is realized not only a cheaper form of transportation, but, in open cars, a more delightful mode of travel between Baltimore and the two most popular camp grounds in Maryland. It will be seen that the chief inspiration of building this railroad lies in the fact that a large volume of traffic was ready to make use of it as soon as completed.

Operations also have begun on what has been called the Baltimore-Washington Boulevard. This magnificent scheme has been reduced somewhat in dimensions until it consists of nothing more than the construction of a double-track electric railway between Baltimore and the national capital. Present indications point to the early completion of the road, possibly by installments, and the establishment of a line of communication in competition with the steam railways. A sufficient motive also exists for the construction of this line. People pass between Baltimore and Washington by the hundred thousand every year. Having a monopoly of the means of communication, the railroads have never reduced the regular fare below $2 for the round trip, and a trolley road between the two cities, passing through several of the growing towns along the way, would open up facilities for travel which would not only be popular, but exceedingly profitable on a basis of $1 for the round trip.

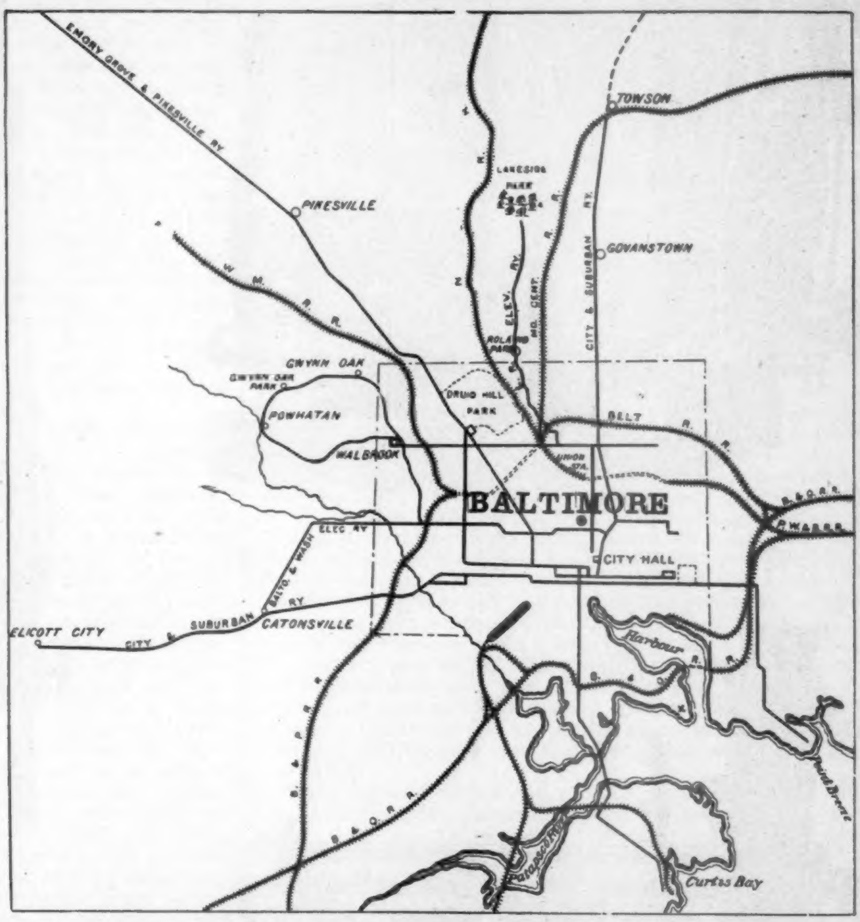
It is quite likely that the steam railways may inaugurate a rate war with the electric line when it is finished, but there will be small chance of the older companies driving the newer one out of the field so long as travel in trolley cars is made comfortable and exhilarating as it now is. To ride in warm weather in a swift-running coach, open to all the breezes of heaven and entirely free from the dust and cinders, would invite patronage even if a higher rate is charged than on the steam railroads. A proposition has been made also to extend the Pikesville & Reisterstown Railway to Westminster and Union Mills, and for the promotion of this scheme a company was organized last fall in Westminster. The managers met a serious difficulty on the threshold of the undertaking by the turnpike company demanding a half interest in the road as a concession for the right of way. But means will be found ultimately to bring the turnpike company to terms, or to take the road into Westminster along some other route, and it is quite likely that the enterprise will develop during the present year. Should this road be built, the way will then be opened to an extension of the line to Gettysburg, when a system of electric transit will have been inaugurated in Maryland which will settle forever certain questions regarding this new mode of transportation.

It will be seen, however, that in constructing the proposed electric railway beyond Reisterstown the chief object sought is not the same which has prompted the investment of capital in the other lines. To that point the management looks only to the carrying of a very large number of passengers to and from the camp grounds at Glyndon and Emory Grove, the connecting of Reisterstown with Baltimore being only incidental to that object, but at Reisterstown conditions change. A railway built to Westminster and Union Mills must depend as much upon carrying freight for revenue as upon carrying pas-

ELECTRIC RAILROADS OF MARYLAND.

sengers. One of these towns is already connected with Baltimore by rail, and passenger traffic alone is not sufficient to warrant the introduction of competition over an electric line, without resort also to the handling of freight. But Carroll County is a dairy region, large quantities of milk being transported at all seasons of the year to Baltimore. It is proposed, therefore, if the line is built, to run milk trains by electricity, and it is possible also that the lighter forms of truck would soon move over the electric road. This constitutes a new departure in the application of trolley roads to local traffic, and it represents the logical outcome of the third stage in the development of this form of transportation.

Examination of a good map will leave the impression that Maryland is pretty well supplied with steam railways, while an appeal to statistics will tend to strengthen that notion. According to the Inter-State Commerce Report for 1893, there were 1,299 miles of railroads within the State. This is 13 miles to each 100 square miles of territory, and about 12 miles to each 1,000 of the population. Comparing these figures with those of other States, there are only a few commonwealths which can boast of greater relative mileage. But the facts are misleading to a certain extent. With the exception of the Western Maryland system, the railroads running into Southern Maryland and a portion of those on the eastern shore, the steam railways of the State are trunk lines, paying small attention to local traffic. It is the winding of the Baltimore & Ohio Railway along the valley of the Potomac for nearly 500 miles, and the passing of the lines of the Pennsylvania system across the State from Washington to the Delaware line, that gives to Maryland its large percentages. The Baltimore & Ohio system skirts the extreme verge of several counties, and affords very poor facilities for local traffic. There is considerable territory in Maryland which has no railway communication at all, and the practical farmers, business men and manufacturers of the Terrapin State, are looking confidently to the building of electric railroads to supply the lack. Conditions are most favorable, therefore, not only for the extension of such lines outward from Baltimore, but for connecting the larger towns of the counties by trolley roads along the turnpikes. There is no hope for the complete accommodation of local traffic, except in multiplying steam railways or having recourse to the new, light-running electric cars.



ELECTRIC AND OTHER RAILROADS RUNNING OUT OF BALTIMORE, MD.

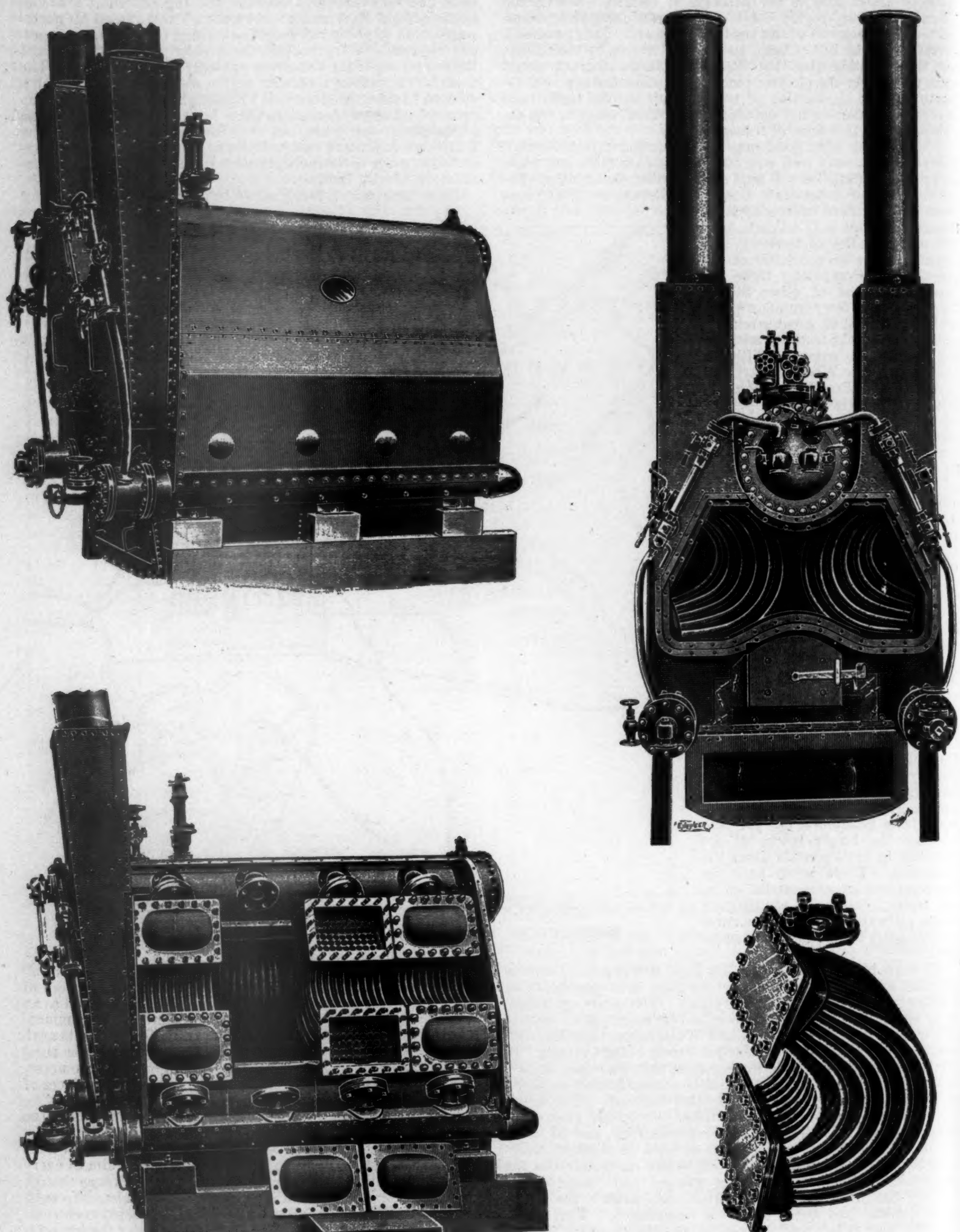
To show how far the matter has gone, it is necessary only to mention some of the projects which have been proposed for building trolley railroads in Maryland. Two years ago a company was formed and stock subscribed for an extensive electric rail-way system in Frederick and Washington counties, connecting Frederick with the principal towns of the Catoctin Valley, and running over into the populous and rich region known as the Middletown District, the whole system finding an outlet at Brunswick on the Baltimore & Ohio Railroad. This ambitious scheme would have accomplished the double purpose of enlarging the field of trade for Frederick City, and of opening one of the richest agricultural sections in Western Maryland to direct communication with better markets. But the undertaking fell through after ground had been broken for the line over Catoctin Mountain, and after a few thousand dollars had been spent in machinery. The panic of 1893 had fallen, and it was impossible to negotiate the securities.

A similar project has been advocated also on the eastern shore of Maryland, to unite the county seats and establish something like a rational system of communication among the towns of that part of the State. A company to promote and build this line is already in existence, though nothing actually has been done toward placing the stock or making capital available for the construction of the lines. The steam railway facilities of the eastern shore are so placed as to interfere with rather than to encourage communication between the Maryland towns and to unite their interests with Baltimore. The main line runs through Delaware, sending out short branches to the several Maryland county seats. These extend far northward ; and to go by rail from Cambridge to Easton, for example, requires one to traverse the greater part of the State of Delaware, while the two cities are only 25 miles apart. The truth is, the railways of this region were built chiefly with a view to running produce into Philadelphia, and the freight accommodations on the eastern shore have not only been a cause of complaint for years, but they inspired the building of the Baltimore & Eastern Shore Railway, and have given an immense impulse to the multiplication of facilities for water communication with Baltimore.

These are two of the most ambitious schemes for building electric railroads outside of the city, though by no means all that have been projected ; and they serve to show the need of better local transportation facilities in Maryland, as well as an eagerness among the people to obtain them. If the commonwealth is to grow and to acquire the population which its agricultural territory is capable of supporting, people in the rural districts believe that something besides wagon roads are necessary between the principal railroad stations and the places of production in the counties.

What is true of Maryland in this respect is measurably true of other States. Steam railroads serve a most useful purpose, but they do not in all cases provide the best facilities for local traffic. Indeed, there are expanses of territory in almost every county in the United States as remote from market as though railroads and improved waterways did not exist. To such localities the light-running electric car on its cheaply constructed roadbed promises relief, and in this particular the long-distance trolley seems destined to become a mighty agency of progress in the United States.

Smokeless Powder.—A number of the largest firms of powder manufacturers are now working hard to produce a satisfactory smokeless powder. None which has yet been made has been satisfactory for the large seacoast guns for which it is most desired.



THE MUMFORD WATER-TUBE BOILER.

THE MUMFORD WATER-TUBE BOILER.

AMONG the various water-tube boilers now in the market, that which we illustrate on page 416 is not the least successful. Like all boilers of the kind, it has been evolved by a series of experiments carried on for many months. The great object sought to be obtained was the production of a boiler which admitted of a prompt and easy repair, while it should not be less economical and efficient than other water-tube boilers. Its principle of construction is so simple that it will be understood from the drawings, almost without a word of description, by any one who is conversant with water-tube express boilers. There are now 11 of them supplying steam to a similar number of engines in the pinnaces of the British Navy; and they have, we understand, up to the present given great satisfaction. They are all worked in close stokeholds with forced draft. It may be added that while two chimneys are shown in our illustrations, one can be used if preferred; but we believe that the Admiralty authorities prefer two.

From the illustrations it will be seen that the boiler is constructed in elements, or groups of tubes, fitted into top and bottom boxes, which are of forged steel, having one inlet in the bottom box and one outlet in the top box. Without lifting the boiler any of these elements or nests of tubes can be disconnected and lowered into the furnace space and removed through the furnace front for repairs without disturbing the remainder of the boiler or necessitating the breaking of any joints beyond the two connected with the element to be removed. By removing the top and bottom covers of the tube boxes a single defective tube in any position can be removed and replaced by a new one without interfering with the surrounding tubes. The boiler can be constructed either with direct through or return draft, and the smoke-box placed at either end, according to the position of the baffle plates among the tubes. There is at the back end a ⊥ down-cast pipe for returning water to the lower feeding tubes.

It might be imagined that the bolted joints would give trouble and cause some delay in putting the parts together. As a matter of fact, by an extremely simple expedient the joints are made perfectly tight without asbestos, cardboard, wire gauze, tape, lead, or cement of any kind, and the faces are not scraped up. The joint can be made and unmade as often as needed without any trouble. A noteworthy feature is the small comparative size of the tubes which supply the lower boxes with water, and deliver steam and water into the steam drum. It might be thought that congestion would take place in the small boiling tubes, and that they would become dry and would burn. But, as a matter of fact, nothing of the kind has occurred. As much as 150 lbs. of coal has been burned per hour per square foot of grate, and 221 lbs. of water per hour have been converted into steam per foot of grate. Then the fire was drawn as quickly as possible, and the boiler cooled down without the least sign of leakage. It is difficult to believe that this quantity of coal could have been burned, but we are assured that there was a very small ejection of cinders. Of course this experiment was carried out with a fierce draft and no idea of attaining economy. In practice, about half the weight of coal is burned, and the economical efficiency is then very good, particularly in the larger boilers. The tubes are of galvanized steel, bent by the makers and rolled into the tube plates. The boiler is a little heavier per square foot of heating surface than some of the other express boilers, but it is lighter than the locomotive type of torpedo boiler. All the details of construction, on which so much depend, have been very carefully worked out. We may add that the boiler is placed at some disadvantage by want of height in the smaller sizes. In larger vessels, such as torpedo catchers and yachts, where plenty of height is available, the economical efficiency of the boiler is greatly increased, and, compared with the power, its weight diminished. In that case a longer boiling tube is used, and the curves are differently arranged. —*The Engineer*.

H.M.S. "POWERFUL."

THE first-class protected cruiser *Powerful*, which was launched at Barrow on July 24, is a sister ship to the *Terrible*, launched from the Clydebank Shipyard on May 28. Both vessels have been built to the same drawings so far as constructional work is concerned, and putting aside the design of the engines and general arrangement of machinery. These vessels are the largest cruisers ever constructed. They have been designed by Sir William White, the Director of Naval Construction. They are each 500 ft. long between perpendiculars, or 538 ft. over all. The width is 71 ft., and the designed draft 27 ft. The displacement at that draft will be 14,200 tons. This is only 700 tons less than our largest battleships of the *Magnificent* class, and about 200 tons less than the Italian vessels of the *Italia* class, for so long the largest war-vessels in the world, which are described as "armored" ships, though they have no armor in the shape of belt or for side protection. The *Powerful* and *Terrible* have a considerable proportion of their displacement devoted to armor, there being the armored deck, with a *maximum* thickness of 4 in., the conning-tower, the barbettes, and the casemates of 6 in. thickness, besides ammunition trunks and additional protective plating at the backs of the casemates and elsewhere. If the tendency toward suppression of side armor in battleships, which was so apparent a few years ago, and of which the *Italia* may be taken as an extreme example, had continued, it would soon have been difficult to draw the line between battleships and cruisers in view of the reduction in calibre of principal armaments. The *Italia* has four 100-ton guns. This alone is sufficient to differentiate her from the *Powerful*, which has no larger weapon than the two 9.2 in. guns mounted fore and aft. The *Italia* is credited with 18 knots on her trial, while the *Lepanto*, a more recent vessel of the same navy, steamed about a third of a knot faster. It is, however, hardly worth while to compare these two vessels, which have fifteen years between the dates of launching, and which have been designed for such different duties, although, in view of the approximation in size and the disposition of armor, the opportunity is somewhat tempting.

In an inspection of the *Powerful* as she stands in the yard of the builders, the Naval Armaments & Construction Company, the first thing that strikes one is the unusual precautions taken to insure safety in launching, a matter which has been enforced upon the attention of shipbuilders by recent events. The launching weight will be about 7,300 tons, and in order to take this the ways have been made no less than 5 ft. wide. The heavy timbers, or "poppets," which form the cradle on which the vessel rests as she is launched are all vertical, in place of their being inclined. On the forward cradle there is a steel plate which is bent to the shape of the vessel, or to a V section. This passes under the bottom, the top edges on each side being riveted to a shelf, which hooks on to the heads of the poppets. The structure is further strengthened by a number of turns of heavy chain, which are attached to the cradle on each side and pass down under the keel of the ship, thus strengthening and supporting the plate. In a long and heavy vessel such as this the necessity for precautions of this nature has been much emphasized of late. When the after part of the vessel is water borne a great strain is thrown on the forward part of the cradle, which might possibly, under certain conditions, give way. Inside the vessel equal precautions have been taken to provide against straining the hull structure itself, the double bottom space being extensively timbered, and the decks strutted throughout with heavy timber balks.

The armament of the *Powerful* will consist of two 9.2-in. guns, twelve 6-in. quick-firing guns, sixteen 12-pdr. quick-firing guns, and twelve 3-pdr. quick-firing guns, with nine machine guns and two lighter guns. The barbette armor for the protection of the bases of the mountings of the two 9.2-in. guns is in place. These weapons are mounted on the upper deck forward and aft, and have, therefore, an extended arc of fire. The armor for the barbettes and conning tower has been supplied by Messrs. John Brown & Co., of Sheffield. It is of Harveyized steel. The rings of armor are composed of four segments, which together form a dwarf roll or cylinder 15 ft. 6 in. diameter and 2 ft. 6 in. deep. The shield for the protection of the gun will, of course, be raised above this fixed armor. The armor plates which form the outside part of the casemates for 6-in. quick-firing guns are very fine pieces of work by Messrs. Cammell, of Sheffield. The twelve 6-in. guns form the chief fighting element of the ship. Eight of these guns are placed on the main deck, four on each side. The two pairs forward and aft are arranged to have a wide range ahead and astern respectively. In order to provide for this the sides of the ship have been recessed so that the forward guns may be pointed well ahead and the aft guns well astern. The armor for these casemates is in two parts, the division being vertical in plane with the axis of the gun. Each of the two plates is about 13 ft. long and 7 ft. to 8 ft. high, the height varying with the position in the ship. As this is 6 in. steel armor, and as the plates have to follow the contour of the ship, which forms a considerable curve at the ends, it will be seen that powerful machinery is required to form these plates; and here it may be said that the modern disposition of steel armor has only been made possible by the improvements of late made in hydraulic presses and special machine tools. The plates are, however, not only bent to a

considerable curve, but the part which would formerly have been cut out to form the gun port has not been entirely removed, but has been bent inward, thus forming very efficient protection to the guns' crews. The design is not altogether new, it having been adopted in some previous cruisers designed by Sir William White, but it is worthy of notice as an example of the difficult work which the steelworker of to-day can perform by means of powerful modern machinery. The broadside casemates, of which there are four in all, form shallow sponsons standing out from the ship's side, thus increasing the range of fire, which amounts to 60°. The four remaining 6-in. guns are mounted in casemates placed immediately above the fore and aft casemates on the main deck. All these casemates have 2-in. armor at the back to protect the crews from splinters of shell or *débris*. The ammunition is brought up through armored trunks, the trunk for the upper deck guns being brought up through the back of the main deck casemates. Dismounting rails are fixed to the deck, and by the aid of these the guns can be slung and traversed back so that they may be housed well inboard outside the casemates.

Turning to the more general features of hull structure, we find that great pains have been taken by skilful disposition of material to get extreme lightness combined with the great strength and rigidity required in a vessel of this nature. The armored deck is, of course, a great feature of strength, and affords an excellent foundation to work from. Under the machinery space there is the usual double bottom, which extends from edge to edge of the armored deck. Above this the ordinary frames are spaced 2 ft., but every sixth frame is a deep web frame stiffened by a reverse angle. These frames are 2 ft. 6 in. deep, and are 12 ft. apart. This form of structure extends from the armored deck to the upper deck.

The armored deck itself is composed principally of three thicknesses of steel plating, but at the edges, where it joins the side of the ship, two of the skins of plating are discontinued, so that the extreme edges of the deck, for a width of a foot or two, are only one skin of plating. This feature, which, presumably, is chiefly to facilitate and cheapen construction and save weight, has been very severely criticised in some quarters; but the objections raised are more apparent than real. With the ship at rest the edges of the deck are a long way below water-level, and it is only when the vessel is rolling that the supposed defects would be manifested. To bring the lower edge of the deck to the surface, however, would require a considerable roll. If the ship were rolling from the enemy the tendency would be to bring the edge of the deck more nearly parallel with the line of fire, when penetration would be far more difficult. If the ship were rolling toward the enemy the high crown of the very much arched deck would have to be surmounted. In these considerations the trajectory of the shot is supposed to be flat; with a plunging fire the danger would be increased, but that applies to deck protection generally. A cruiser, not being designed for the line of battle, must take its chance. There is, however, another argument to be advanced in favor of the thin edges—namely, that a shot penetrating them would not pass into any of the large compartments of the ship, but into the double bottom space, unless, of course, it pierced both the inner and outer skin. Whether the thinner edges for the armored deck are or are not a desirable arrangement may be a matter of opinion, but the points now advanced are worthy of attention in view of the fact that only adverse criticisms have been hitherto heard.

The machinery space occupies about half the length of the ship—240 ft.—and this, of course, in the middle part of the vessel. Such is the price paid for high speed. The coal capacity of these vessels is very large, the *maximum* amount carried being 3,000 tons. A good deal of this coal is utilized as protection against the destructive effects of shell fire. At the time of launching the ship will be far nearer completion than is often the case with vessels of this kind. All the armor proper is in place, pedestals for gun mountings, skylight and companion ways, etc.; even a great part of the joinery work is fitted. In regard to the latter great pains have been taken

A HOME-MADE YARD CRANE, CENTRAL VERMONT RAILROAD.

to reduce the quantity of wood used as much as possible. The necessity for this has been amply proved during the recent war in the East between China and Japan. To the credit of the Admiralty it may be said, however, that this was previously recognized, and Sir William White had made provision for reducing the risk of fire during action before the late war began. In the *Powerful* steel panels are largely used in place of wood for cabin partitions, etc., and sheet-steel is largely used in all places possible.

The ship has been constructed under the inspection of Messrs. Millard & Daily, of the Controller's Department at the Admiralty, Mr. Adamson being managing director for the contractors. M. A. B. Gowan has had charge of the shipbuilding department as works manager.

The engines of the *Powerful*, which consist of two pairs of three-stage compound engines, designed by Mr. A. Blechynden, have cylinders 45 in. high-pressure, 70 in. intermediate, and two low-pressure cylinders each of 76 in., the stroke 48 in. These incorporate the modern features of steel in place of iron and large bearing surfaces. The boilers are, as in the *Terrible*, of the Belleville type. As in the *Terrible*, there are 48 in all, in eight water-tight compartments. A more extended description of the machinery may be left until its performance is proved by the trial trip of the vessel. It may be stated, however, that there are 144 steam cylinders in the main and auxiliary engines, the former, however, contributing but eight of these. The boiler pressure will be 260 lbs. to the square inch, with reducing valves to bring it down to 210 lbs. in the cylinders. The total I.H.P. will be 25,000 at 110 revolutions. The legend speed is 22 knots.—*London Times.*

YARD CRANE, CENTRAL VERMONT RAILROAD.

In our last issue we illustrated a home-made wrecking crane that is in service on the Central Vermont Railroad, and which is doing satisfactory service. In the St. Albans yard there is a crane made at the shops there that may serve as a hint to those who must have a crane and who are compelled to build for themselves. The illustration on the opposite page gives a very clear idea of the construction. Like the wrecking crane, it turns upon a central post that is firmly attached to the framing of the car, but while the thrust of the former is taken up at the foot of the boom, the weight supported by this one is counterbalanced by the weight in the box at the back of the cranks. In order that a balance may be secured under all variations of load, the boom and the counterweight-box can be racked back and forth on the framing that is fastened to the central post, and the leverage of the weight thus varied to suit the circumstances of the case in hand. The crane is mounted upon a four-wheeled car with the pedestals attached directly to the side-sills, as shown. A brake consisting of a stick pivoted at one end, and having a bearing on the driven gear of the drum, serves to hold the load and to lower the same. The car is so light that it can easily be pushed from one point to another without a locomotive, and is used for handling heavy weights between the trucks and the cars.

NEW COMPOUND LOCOMOTIVES FOR THE ST. GOTHARD RAILROAD.*

By Edward Sauvage.

The St. Gothard Line, between Lucerne and Chiasso, is composed of sections where the grades do not exceed 1 per cent., and of others where the inclination is 2.6 and even 2.68 per cent. From Lucerne to Erstfeld we have a level stretch of 41.3 miles where the grades do not exceed 1 per cent., and which consists of the section from Lucerne to Immensee, which does not belong to the St. Gothard Railroad, and the section from Immensee to Erstfeld. The St. Gothard Company is about to build a new line from Lucerne to Arth-Goldau (5½ miles beyond Immensee), which will run close to Lake Geneva, and will be shorter than the present line. From Erstfeld to Goeschenen the road rises, in a distance of 18 miles, from an altitude of 1,560 ft. to 3,632 ft., giving an average gradient of 2.19 per cent., while the actual grades are as much as 2.6 per cent. Between Goeschenen and Airolo (a distance of 9.32 miles, of which 8 7 miles is in the great tunnel) there is a grade of .58 per cent. for a considerable distance, followed by inclinations of from .05 to .2 per cent. From Airolo to Biasca, a distance of 28.33 miles, the road descends from an altitude of 3,756 ft. to one of 971 ft., over an average grade of 1.86 per cent., but which in some places is as much as 2.68 per cent.

From Biasca to Bellinzona the steepest grades are only .08 per cent. In like manner the branch lines running from Bellinzona to Locarno and Luni are practically level.

The line from Bellinzona to Chiasso is undulating; it rises to an altitude of 1,560 ft. to drop again to 787 ft. Between Bellinzona and Lugano the gradients rise to as much as 2.6 per cent. in one direction and 2.1 per cent. in the other; they are 1.67 per cent. between Lugano and Chiasso.

The average speed between two stations on the heavy grades is actually from 18.6 to 21.1 miles per hour for the fastest express trains; two locomotives are used, and sometimes three (two at the head and one at the rear of the train) when the weight of the express trains exceeds 90 gross tons. The engines are changed at Erstfeld and at Biasca, at the foot of the heavy grades.

The management of the St. Gothard Railroad desires to make certain of hauling express trains by locomotives powerful enough to increase the average speed, and at the same time make double-heading less frequent, and fast enough upon the level lines to avoid the necessity of relays at the foot of the heavy grades. Two compound engines have been built for this purpose and are now on trial.

These two engines have boilers of identically the same dimensions; they are very large and intended for a pressure of 196.5 lbs. per square inch; they are carried upon three coupled axles and a bogie. One of them has four cylinders, two high pressure on the inside, having a diameter of 13.8 in. with a stroke of 23.6 in., and the two outside low-pressure cylinders have a diameter of 20 9 in., with a stroke of 23.6 in. The other engine has three cylinders, one being a central high-pressure cylinder of 17.3 in. diameter, and two low-pressure cylinders that are smaller than those on the other engine; their diameter is 18.9 in. The stroke of all of the pistons is 23.6 in.

The diameter of the driving-wheels is 5 ft. 3 in. The connecting-rods of the low-pressure outside cylinders are connected to crank-pins on the second drivers; the first axle is, on the other hand, a crank axle, and is driven by the connecting-rod or rods of the high-pressure cylinders.

A special apparatus permits direct steam to be admitted to and the exhaust to be led from all of the cylinders.

Fig. 1 is a longitudinal section, fig. 2 the plan, and figs. 3 and 4 cross sections of the three-cylinder machine, while fig. 5 is a side elevation of the two engines. The principal dimensions of these locomotives are as follows:

Heating surface of fire-box		132.4 sq. ft.
" " " tubes (inside)		1,485.4 sq. ft.
Total		1,617 8 sq. ft.
Number of tubes		244
Internal diameter of tubes		1.77 in.
External " " "		2 in.
Length of tubes		13 ft. 1⅛ in.
Grate area		24.75 sq. ft.
Steam pressure		196.5 lbs. per sq. in.
Diameter of driving-wheels		5 ft 3 in.
" " truck "		2 ft. 9⅛ in.
Rigid wheel base		1' ft. 6.6 in.
Total " " of engine		28 ft. 6.1 in.
Diameters of cylinders:		
Four-cylinder engines	2 high pressure	13.8 in.
	2 low "	20.9 in.
Three " "	1 high "	17.3 in.
	2 low "	18 9 in.
Stroke of all pistons		23.6 in.
Weight, empty		About 59 gross tons
" in working order		" 65 " "
" on drivers		" 45 " "

TENDER.

Diameter of wheels	3 ft. 4.2 in.
Total wheel base	10 ft. 6 in.
Coal capacity	5 gross tons.
Capacity of tank	3,960 galls.
Weight, empty	About 13 gross tons
" loaded	" 33 " "
Total length of engine and tender	50 ft. 2¾ in.
" wheel base of engine and tender	40 ft. 8 in.
Total weight of engine and tender:	
Empty	About 72 gross tons
In working order	" 98 " "

The valves are of the Allen type, are made of cast iron placed over the cylinders, and are operated by the Walschaert gear, with balancing strips on the top.

The engines are equipped with the Westinghouse-Henry automatic and adjustable brake.

Among the details of construction we would call attention to the following:

The tires are rolled with an external lip and are fastened by

* From the *Revue Générale des Chemins de fer.*

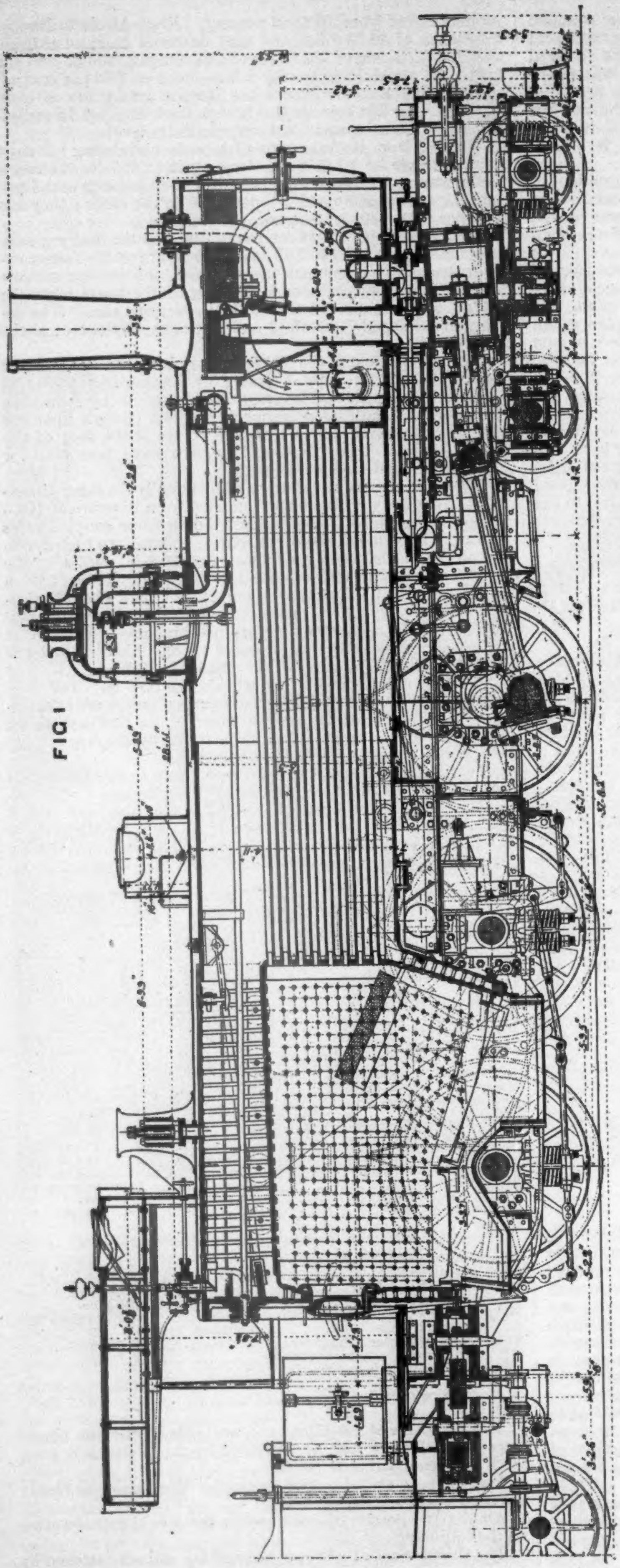


FIG I

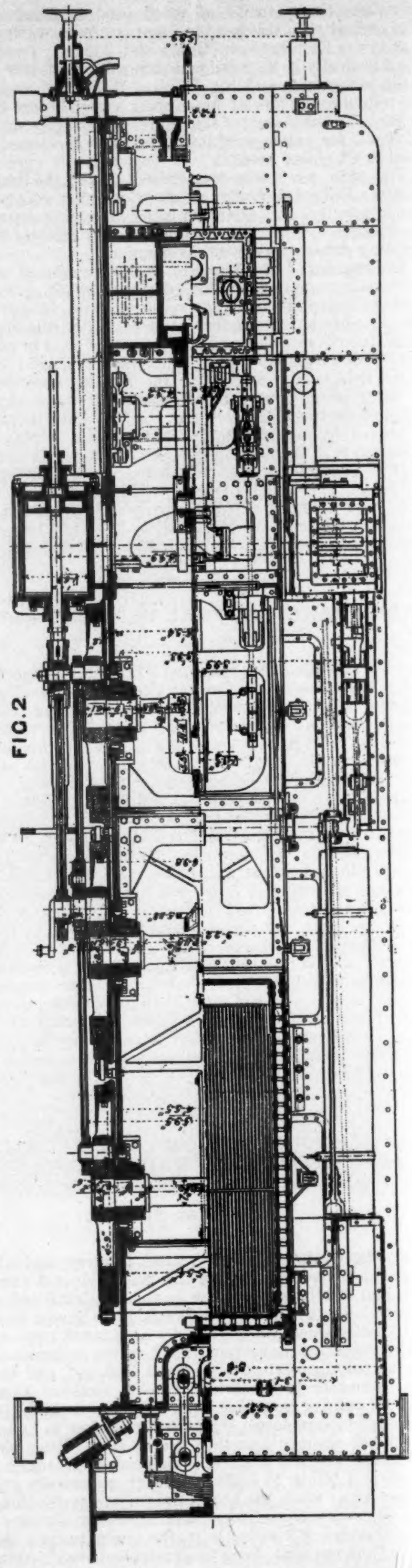


FIG. 2

THREE-CYLINDER COMPOUND LOCOMOTIVE FOR THE ST. GOTHARD RAILWAY.

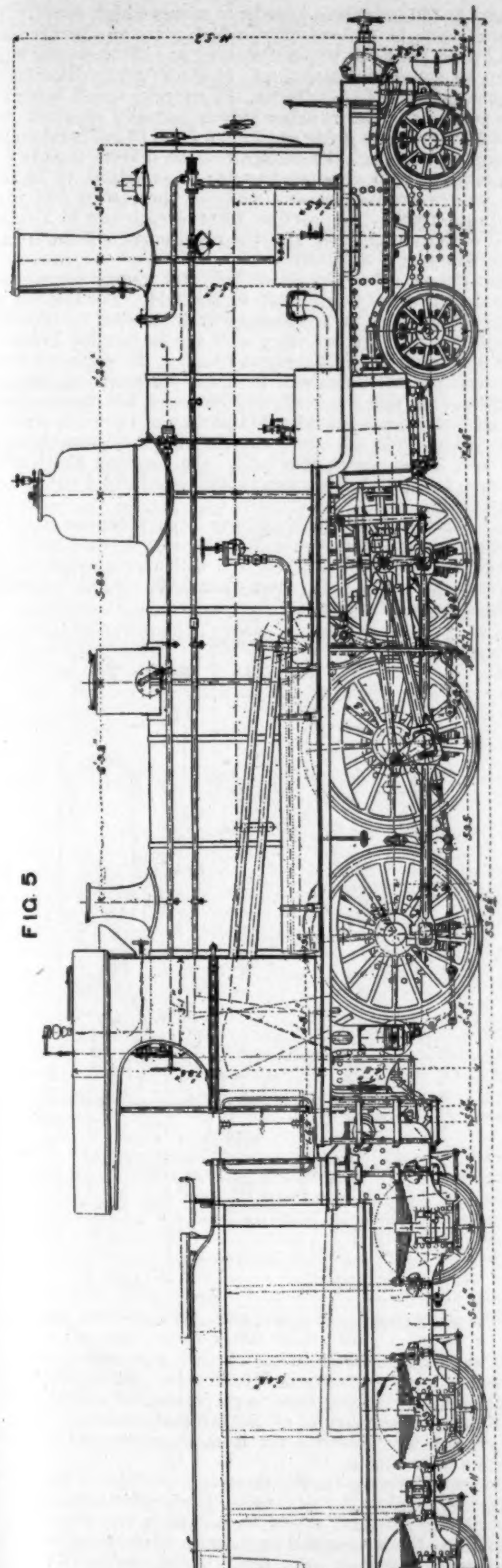


FIG 5

TEN-WHEELED COMPOUND LOCOMOTIVE FOR THE ST. GOTHARD RAILROAD.

turning it down upon an iron ring made in several pieces, according to the standard system adopted in Switzerland. The engine is hung upon coiled springs applied to the driving axles and to those on the bogie. The arrangement for the former is very simple, the springs being placed under the boxes; it is less so for the bogies. The engines ride very easy. In the tests to which they were subjected these carrying springs

FIG. 3.

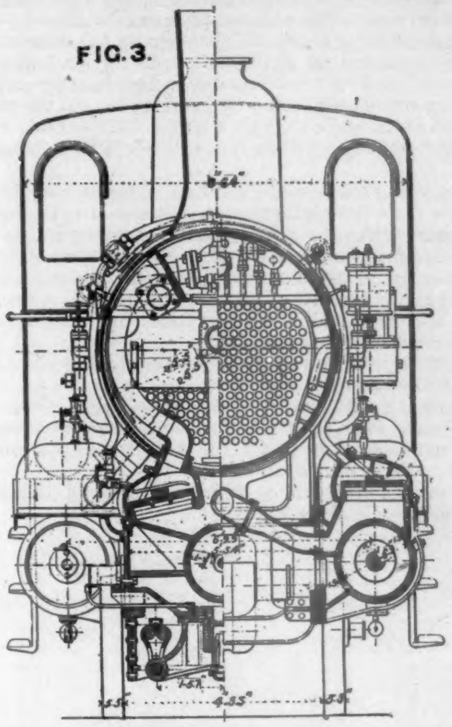
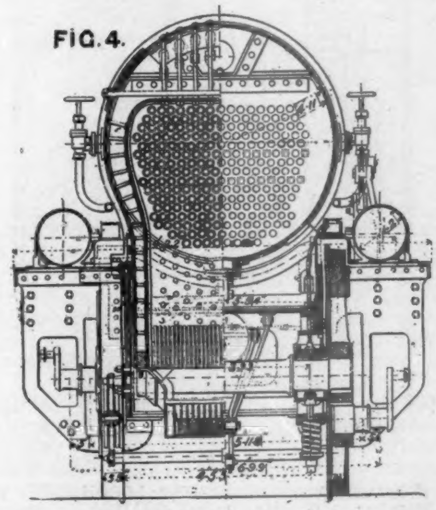


FIG. 4.



CROSS-SECTIONS OF COMPOUND LOCOMOTIVE FOR ST. GOTHARD RAILROAD.

showed that under a load of 2,000 lbs. the double-driver springs gave a deflection of .43 in.; under 4,000 lbs., .82 in.; under 6,000 lbs., 1.25 in.; and under 8,000 lbs., 1.57 in. The single bogie springs under a load of 2,000 lbs. deflected .79 in.; under 4,000 lbs., 1.42 in.; and under 5,000 lbs., 1.68 in.

The bogie has a lateral swing controlled by hangers. The bogie wheels pass beneath the frames of the engines. The bogie frame carries large fenders of sheet metal that are nearly vertical, and which stand at an angle with the rail so as to throw all obstructions to the outside. This is the regular arrangements on the St. Gothard locomotives.

The boiler has a large diameter (4 ft. 11 in. for the inside of the smallest ring). As the fire-box cannot be introduced through the bottom opening, the back sheet of this box is so flanged that it can be easily riveted from the outside after the box has been put in position. There are four direct-loaded safety valves, having a diameter of 2¼ in. The smoke-box is long. An ash-pan is placed behind the grate openings which

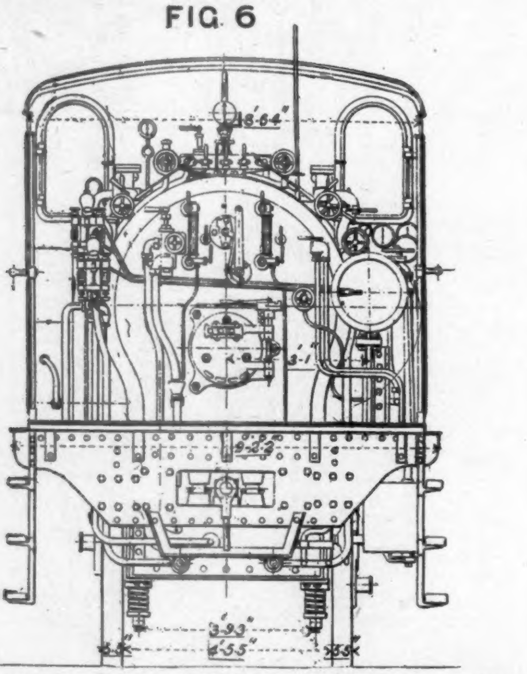
catches the ashes as they fall. The boiler is fed by three injectors; and it is often found to be necessary to use two at the same time, the third being held in reserve. There are two water glasses, with a mark showing the lowest level for water on an up grade of 2.7 per cent.

In order to insure sufficient adhesion, the engines are fitted with an apparatus for washing the rails throwing a stream of water between the wheels of the bogie, and a pneumatic sander for the drivers. The exhaust pipe can be closed by a clapet valve operated by hand, which opens at the same time a pipe for the admission of air. The reversing mechanism for the two sets of high and low-pressure cylinders is operated by two reversing screws connected by gearing, so that the two can be operated at the same time by a single hand-wheel, while they may be disconnected when it is so desired, to be worked separately.

The starting mechanism is such that steam may be exhausted direct from the high-pressure cylinder or cylinders into the atmosphere without sending it into the receiver. At the same time steam may be admitted into this receiver directly from the boiler by means of a special throttle of small dimensions. The apparatus consists of pistons which work upon a cock in such a way as to realize the four following combinations:

1. Normal compound action.
2. Running with the high-pressure cylinders alone, exhausting directly into the atmosphere.
3. Running with the low-pressure cylinders alone, by opening the small supplementary throttle. The apparatus remains in the same position as for the second combination, and the main throttle is kept shut.
4. Running with direct admission into all the cylinders, the main throttle alone being open.

FIG. 6



REAR ELEVATION OF COMPOUND LOCOMOTIVE FOR ST. GOTHARD RAILROAD.

The lubrication of the valves and pistons is accomplished by two condensing lubricators with sight feeds and placed in the cab.

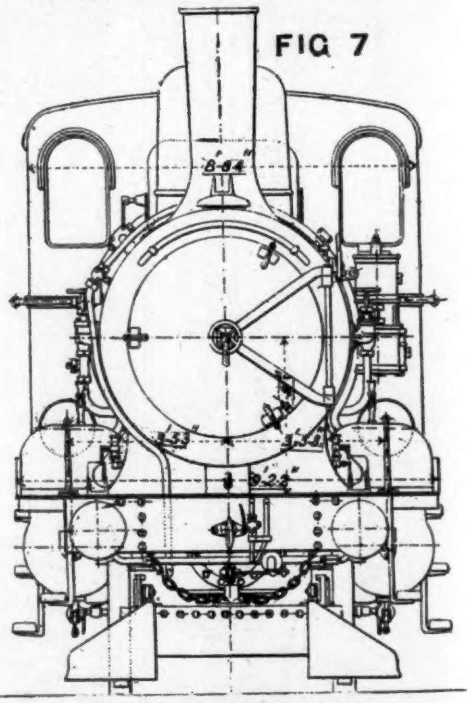
A special train weighing 120 gross tons was hauled from Erstfeld to Goeschenen by the four-cylinder engine. With the engine and tender the total weight was 215 gross tons. The running speeds were taken by means of a Klose apparatus. The 18 miles were run in 44 minutes, giving an average speed of 24.54 miles per hour. Between Erstfeld and Amsteg, where the heavy grades are not continuous, the speed rose to from 31 to 40 miles per hour; from Amsteg to Gurtnellen it averaged about 20 miles; it rose to 31 miles while crossing the yard of the Gurtnellen station; a little further on there was some slipping; the speed is maintained at about 22.37 miles on up grades of 2.5 and 2.6 per cent.; it rose above 37.3 miles at the Wassen station, to drop back to from 23.6 to 24.8 miles on grades of from 2.2 to 2.5 per cent. A short distance beyond Wassen, in the spiral tunnel of Leggistein, the engine slipped several times, the grade being one of 2.2 per cent.

For the run from Goeschenen to Airolo, a distance of 9.75 miles, with a grade of .6 per cent., the weight of the train was reduced to 100 gross tons in order to secure a high speed. The run was made in 13.5 minutes, which gives an average speed of 43.5 miles per hour, without making any allowance for working up to speed and stopping. In the opposite direction the run was made in 12.5 minutes, the average speed being 46.6 miles per hour. The running speeds actually obtained were about 47.25 miles in going, and from 50 to 56 miles returning. The engine, although the diameter of the drivers is only 5 ft. 3 in., worked well at these speeds; it sustained, to be sure, some violent oscillations at times, but these were due to defects in the track. The section from Goeschenen to Airolo is almost entirely in tunnel, and the maintenance of the track is consequently very difficult.

Finally the sheet of the Klose indicator shows the evenness of the descent from Goeschenen to Erstfeld. For this run the engine was doubled on a passenger train hauled by the other compound; with the indicator and the adjustable brake the speed was held very uniformly at 28 miles, the engineers being allowed to run at the rate of 29 miles per hour. At some of the stations the speed was slightly increased because the brake was released when a considerable portion of the train was still on the grade. The effective pressure on the adjustable brake was about 14 lbs. per square inch. On reaching Erstfeld the tires were found to be so warm that the hand could not be held against them.

From the verbal reports that have been given me, the consumption of fuel and water for the rise from Erstfeld to Goeschenen, at the speed given, and with a train weight of 120 gross tons, was but a little more than 2,200 lbs. of briquettes and 2,110 galls. of water.

FIG 7



FRONT ELEVATION OF COMPOUND LOCOMOTIVE FOR ST. GOTHARD RAILROAD.

The experiments with these engines were not prolonged sufficiently to get perfectly definite results. The engineers on the St. Gothard Railroad seem to prefer the four-cylinder locomotive, perhaps on account of the larger diameter of the low-pressure cylinders, which gives it more power and a better utilization of its steam.

From what I have seen, the steaming qualities of the boiler seem to be ample. As a vehicle, the engine passes easily around the curves and seems to be stable and steady; the combination of three-coupled axles brought near together with a bogie truck is a good principle. These compound engines appear to satisfy the conditions demanded, to wit: great power for climbing grades combined with a facility for running at high speeds over the easy portions of the line.

Since the above was written new experiments have been made by the St. Gothard engineers, resulting in some modifications in the engines. The three-cylinder locomotive, which was found to be too weak, has been adjusted to run continuously with a direct steam admission into the three cylinders, while the four-cylinder locomotive, which appears to have given better results in service, is worked exclusively as a compound.

M. Dubois, Engineer for the Western Railway of France, who has recently visited the St. Gothard Railroad, has handed me the following report:

Conditions imposed upon building.

To haul 120 gross tons at a speed of 25 miles per hour on 2.5 and 2.7 per cent. grades.

To haul 200 gross tons at a speed of 37 miles per hour on 1 per cent. grades.

To haul 200 gross tons at a speed of 56 miles per hour on the leve! and up grades of .5 per cent.

AVERAGE OF RESULTS OBTAINED IN 12 TESTS BETWEEN ERSTFELD AND GOESCHENEN.

Engine.	Load.	Time of Run in Minutes.	Distance.	Consumption	
				Water.	Coal.
4 Cylinder..	120 gr. tons	43.8	18 miles	16,082 lbs.	2,662 lbs.
3 " ..	119 " "	44.2	18 "	19,169 "	2,965 "

In tests with the four-cylinder engine the consumption was lowered to 2,350 lbs. of coal and 15,620 lbs. of water.

With this same engine they have been able to go up a grade of 2.6 per cent. with a load of 120 gross tons at a speed of 34.2 miles per hour. The cut off was at 60 per cent. of the stroke in the low pressure and 55 per cent. of the same in the high-pressure cylinders.

With a cut off at 70 per cent. of the stroke in the low pressure and 65 per cent. in the high-pressure cylinders they have succeeded in hauling 135 gross tons up the same grade of 2.6 per cent. at a speed of 25 miles per hour. The maximum speed thus far attained is 65.25 miles per hour. The engine has been run over curves of 984 ft. radius at a speed of 53 miles per hour.

THE BALDWIN-WESTINGHOUSE COALITION.

Since our last issue an alliance of the Baldwin Locomotive Works with the Westinghouse Electric Manufacturing Company has been announced. The combination, it is said in the Philadelphia papers, is not a consolidation of their great companies, but "an industrial combination," in which both companies will mould their resources to a common end. The Baldwin Company will build the running gear, etc., of electric motors, and the Westinghouse Company will supply the electric apparatus. Mr. David L. Barnes, the well-known mechanical engineer, has been appointed a joint engineer for the two companies, and seems to occupy the position of a sort of mechanical umpire in the great game which is thus opened.

The Baldwin Locomotive Works are, of course, well known as being the largest locomotive works in the world. The Philadelphia *Press* gives the following particulars about the Westinghouse Company:

"The Westinghouse Electric & Manufacturing Company was incorporated in 1891 for the manufacture and sale of machinery and appliances for the generation, transmission, and utilization of electricity. The plant of the concern is in Pittsburg, and employs 4,000 men. The Company also operates under lease agreements the factories of the United States Electric Lighting Company, at Newark, and the factory of the Consolidated Electric Light Company, in New York, in the name of the Sawyer-Man Electric Company, employing at these plants an average of 800 men.

"The capital stock is $10,000,000, of which there is preferred and assenting $9,727,450, and common stock (outstanding), $272,550. Its charters, franchises, and patents are estimated to be worth $4,379,831.69. The total assets at the last statement were stated at $14,722,314.48, the surplus being $3,822,049.38.

"George Westinghouse, Jr., is the President; Lemuel Bannister, of Pittsburg, First Vice-President and General Manager; George W. Hebard, New York, Second Vice-President; P. F. Kobbe, Treasurer; Charles A. Terry, Secretary and Attorney, and P. H. Kecham, Auditor. The Directors are: Charles Francis Adams, Boston; Lemuel Bannister, A. M. Byers, George Westinghouse, Jr., Pittsburg; August Belmont, Marcillus Hartley, George W. Hebard, Henry B. Hyde, Brayton Ives, New York, and N. W. Bumstead."

"The kind of locomotive," it is said, "which the combined plant of the Westinghouse and Baldwin Companies will produce will be practically of the same type as the experimental locomotive used on the New York, New Haven & Hartford Railroad, on the Nantasket Beach extension. A locomotive of similar construction will probably be adopted on the Burlington & Mount Holly branch of the Pennsylvania Railroad, upon which the overhead electrical equipment has been adopted as an experiment."

Doubtless the two companies will be guided by the development of the science and the art of what may be called electric motivity, and it would be very unlike Mr. Westinghouse if he did not make some important improvements in electric motors if he undertakes to design or build them.

This combination seems to be an official notice "sealed, signed, and delivered," that electric locomotives have come to stay, and are expected to arrive in large numbers in the future, and to "abide with us."

THE RAILWAY RACE TO ABERDEEN.

By Charles Rous-Marten.

Seven years have passed since the famous railway race from London to Edinburgh excited the interest of the whole civilized world. A new race to Scotland is now proceeding without any loud flourish of trumpets or special glorification in print, yet it is a far more important trial of strength and on a scale of far greater magnitude than its predecessor of 1888.

The race is between the East and West Coast routes. The Midland Line does not enter into the competition. Greater distance and severer grades put it virtually out of the running. But the East and West Coast routes are fighting out the matter to the bitter end, and with a grim and silent determination that seems to bode a tough and prolonged struggle.

It is not quite easy to understand how or why the contest started. Something of the kind has seemed inevitable ever since the completion of the Forth Bridge and new Tay Bridge gave the East Coast a shorter road by 17 miles, with easier gradients than those of the West. But the prospective combatants appeared to hang back, each unwilling to be the first to begin the fray and to disturb the blissful peace which had so long prevailed. For "the land had rest seven years"—ever since the race to Edinburgh in 1888.

Up to July 1 the respective transit times from London to Aberdeen were: East Coast, 11 hours 35 minutes; West Coast, 11 hours 50 minutes. But on July 1 the West Coast unexpectedly shortened the time by 10 minutes. The East Coast promptly replied by bringing down its time to 11 hours 20 minutes. Thereupon, on July 15, the West Coast made a bold stroke, and suddenly announced that 40 minutes would be knocked off the time to Aberdeen at one fell swoop, bringing it down to 11 hours exactly for the 540 miles. The East Coast companies instantly took up the challenge and cut down the time for their 523 miles to 10 hours 45 minutes. That was on July 22. The rejoinder was swift. The West Coast began on the same day running its trains in 10 hours 35 minutes. Once more the East Coast picked up the glove and replied with a reduction to 10 hours 25 minutes, but the West Coast made a simultaneous shortening to 10 hours 20 minutes.

Further accelerations are, however, highly probable. An ultimate consequence is, of course, inevitable, because neither side can arrange finality. But each side has still several cards to play before all competitive possibilities are exhausted. Indeed, on one occasion certainly, if not more, the run has been made in 10 hours or less.

In the first place, it should be clearly understood that the two routes are far more nearly matched than is generally supposed. It is commonly, and not unnaturally, imagined that a route shorter by 17 miles and having easier gradients would confer on the East Coast so great advantage as to render competition hopeless on the part of the West. Not at all. The East Coast, though a shorter and more level road, is handicapped in several respects. It has the troublesome "back shunt" of Newcastle, many miles of single line, and numerous awkward curves on the North British section, shorter runs without a halt, an additional stop, and the necessity of running the last 40 miles or so on the hostile road; while the West Coast has longer runs through the use of the water troughs and scoops, and is free from all those drawbacks just set forth. So, on the whole, the West Coast is perhaps the easier route to work, and hitherto the proved facts have supported that *à priori* theory. This will be readily perceived on perusing the figures shortly to be given.

On July 15 the East Coast express, leaving London at 8 P.M., was timed to reach Aberdeen by 7.20 A.M., the West Coast train leaving at the same time was due at 7 A.M. The former was in punctually, but when it arrived the West Coast train had already been at the Aberdeen platform 34 minutes. Next day the East Coast train again came in punctually at 7.20 A.M., but the West Coast train arrived 39 minutes before its due time—*i.e.*, at 6.21 A.M., or 59 minutes before its rival. Other

West Coast arrivals during that week were at 6.35, 6.28 and 6.43, the nominal arrival time nevertheless remaining at 7 A.M.

It was on July 22, however, that the race began to assume its closest and most interesting phase. On that evening the 8 P.M train from King's Cross was booked to reach Aberdeen at 6.45 A.M., but the same morning the West Coast express was announced to arrive at 6.35 A.M., or 10 minutes earlier than its rival. There was a general understanding that each line would do its best to beat the other to the Kinnaber Junction, whence both have to travel on the same rails, and where, consequently, though 40 miles from the goal, the race is already decided by priority of arrival and precedence of passage.

Chief interest on that occasion attached to the East Coast train, and a large crowd assembled at King's Cross to witness its departure, as a rumor had gained wide currency that a special effort was to be made to score a record. The load consisted of nine six-wheeled E. C. J. S. coaches, one six-wheeled sleeping car, and one eight-wheeled sleeping car—total weight, 179 tons, exclusive of engine and tender. The locomotive was one of Mr. P. Stirling's celebrated 8-ft. "singles," No. 545. Two strokes of ill luck were encountered, by which fully 12 minutes were lost. At Essendine—midway up the Stoke bank —the train was stopped by signal, owing to the tail lamp being out. This caused a loss of six minutes. Later, a bridge being under repair, two stops had to be made to shunt on to the up line and off again, as only a single line was working. This lost six minutes more ; and the two delays practically spoiled the run.

From Grantham another 8-ft engine, No. 775, took the train on to York in 87 minutes, and thence a Northeastern 7 ft. 7 in. single, No. 1,518, continued the journey to Newcastle, making the run in 92 minutes, notwithstanding the loss of six minutes through the bridge repairs already mentioned. At Newcastle two engines came on—a 7 ft. 7 in. single compound, No. 1,525, and a new 7 ft. coupled, No, 1,625—and these ran the train without a stop to Edinburgh (124¼ miles) in 2 hours 16 minutes, arriving in 7 hours 39 minutes from London. Thence No. 211, a new North British 6 ft. 6 in. coupled, took the train the rest of the way, reaching the Aberdeen ticket platform at 6.39 A.M., just one minute after the West Coast train had entered the station, where the East Coast train finally landed its passengers at 6.44, having thus accomplished its journey one minute under time, and yet being beaten by six minutes.

It will be interesting to take next one of the West Coast runs, made while the same times were in force. In this instance the load was a light one, consisting of one eight-wheeled sleeping car, three ordinary eight-wheeled W C. J. S. coaches, and one six-wheeled van ; total, approximately 112 tons exclusive of engine and tender. The special feature of the route consisted in the remarkable length of the runs without a stop. The first was from Euston to Crewe, 158 miles ; the second, Crewe to Carlisle, 141¼ miles ; the third, Carlisle to Stirling, 117¾ miles. Thus a total distance of 417 miles was run with only two stops, a feat never before equalled in Great Britain, and of course only practicable through the use of Mr. Ramsbottom's pick-up scoop and water troughs.

The engine at starting from Euston was the *Mercury*, one of Mr. Webb's 6 ft. 6 in. coupled of the *Precedent* class, whose excellent work I have recently had occasion to record in these columns. The first hour's performance was in some respects without any parallel in my experience. During those first 60 minutes a distance of 58¼ miles were covered, the greater part of which is uphill. Even with a load of only 112 tons, to maintain a speed of 60 miles an hour for many miles up a rising gradient of 1 in 330, as was done on this occasion, is a feat unique in my observations. Thus the 10¼ miles uphill from Watford to Berkhampstead were covered in exactly 10 minutes 30 seconds, and Tring—31¾ minutes—was passed in 35 minutes 17 seconds from Euston, Bletchley—46¾—in 48 minutes 58 seconds, and the 58¼ mile-post in exactly 60 minutes. That the engine was being pressed to its utmost was plainly perceptible, but—the work was done. At this point the speed was "eased off," and the rest of the journey to Crewe was performed at a very moderate pace, the 99¾ miles of extremely easy road occupying 1 hour 57 minutes. Crewe was thus reached in 2 hours 57 minutes 35 seconds from Euston. Here another *Precedent*, the *Hardwicke*, came on, and once more a remarkable "spurt" was made at starting, the first 26 miles being run in 25 minutes. And here again there was then an easing off. After Wigan was passed the train merely ambled along to Carlisle, reaching the station at 1.52.29—*i.e.*, in 2 hours 49 minutes 55 seconds from Crewe.

At Carlisle a Caledonian engine took charge, No. 90, one of the fine 6 ft. 6 in. coupled bogies designed by Mr. D. Drummond. Some exceedingly smart work followed. Beattock Summit 49¾ miles, was passed in 57¾ minutes, the speed never falling below 34 miles an hour up the long bank of 1 in 75. Carstairs, 73¼ miles, was passed in 80 minutes from Carlisle, and Stirling, 117¾ miles, was reached in 2 hours 11 minutes. The hilly run of 33 miles thence to Perth was done in 39½ minutes. At Perth another 6 ft. 6 in. bogie, No. 66—the first of the class ever built—took up the running, and did the 32¼ miles to Forfar in 33¾ minutes, finishing with the 57¼ miles of up and down road to Aberdeen in 65 minutes. The train arrived at Aberdeen by 6.43, or 17 minutes before time.

Next came the response of the East Coast on July 29, the first occasion on which a train has ever been timed to reach Edinburgh in 7¼ hours from London, or Aberdeen in 10 hours 35 minutes. Once more considerable excitement prevailed at King's Cross terminus, the engine being literally mobbed by admiring spectators, and railway magnates being plentiful as blackberries on the crowded platform. On this occasion the work laid out was far more severe than had ever before been prescribed for a Great Northern engine, taking into consideration the load and the speed. Grantham was to be reached in 1 hour 56 minutes, and York in 3 hours 28 minutes. This was not surpassed even in the race to Edinburgh in 1888, when the loads were comparatively light. In the present case the load again numbered 11 vehicles, weighing 179 tons, equivalent practically to fifteen 12-ton coaches, or 18 of the coaches which at the Newark brake trials were used for the "15-coach test." The engine employed was No. 874, one of Mr. Stirling's 7 ft. 7 in. singles, with inside cylinders (18 × 26 in.), and no bogie. It may be remembered that other engines of this admirable and very economical class have 18½ in., 18¾ in. and 18¼ in. cylinders, so that this was one of those having smallest tractive force. Nevertheless it proved more than equal to the heavy demand made upon its capacity. The two-mile bank of 1 in 105 and 1 in 110 out of King's Cross and through the two tunnels was ascended without assistance, and the Potters Bar summit (12¾ miles) was passed in 18 minutes 43 seconds ; Hitchin (32) in 37 minutes 10 seconds ; Peterborough (76¼) in 79 minutes 20 seconds ; and Grantham (105¼) was reached in 1 hour 52 minutes 44 seconds, a remarkable performance with so heavy a load. Here No. 1,002, an 8-ft. single, but not one of the newest and larger class, came on. Newark (14¾ miles) was passed in 15¼ minutes from the fresh start ; Retford (33¼) in 34 minutes 57 seconds ; Doncaster (50¾ miles) in 51 minutes 59 seconds ; the arrival at York (82¾ miles) being in 85 minutes 59 seconds from Grantham. The complete run from King's Cross to York was thus made in 3 hours 23 minutes 42 seconds.

At York an additional coach was attached, making the total load 195 tons, with No. 1,522, one of Mr. Worsdell's celebrated 7 ft. 7 in. singles, originally a compound, but now I believe converted into a non-compound. A mistake was plainly made here in not taking a pilot, for time was steadily lost all the way, until on passing Durham the loss was no less than eight minutes. Down hill to Newcastle a minute was pulled up, but the arrival there was still seven minutes behind time. Two engines then came on, Nos. 1,621 and 1,525—the one a 7-ft. coupled, the other a 7 ft. 7 in. single as in the former case —and a very fine run of 2 hours 15 minutes was made to Edinburgh (124¼ miles), but the complete trip to Edinburgh was spoiled by the needless loss of seven minutes on the York-Newcastle length.

A division was made at Edinburgh, and No. 212, another of the powerful new North British 6 ft. 6 in. coupled bogies, built by Mr. Holmes, took on the 147¼ tons still left. Dundee (59¼ miles) was reached as before in 70¼ minutes, and Aberdeen ticket platform at 6.19 A.M—*i.e.*, in 10 hours 18 minutes from London. But for the loss of time above noticed, Edinburgh would have been reached in 7 hours 25 minutes, and Aberdeen in 10 hours 12 minutes.

Lastly, I must chronicle the most remarkable, though not the quickest, performance by the West Coast route—that of July 26 and 27. On that occasion the load practically equalled the average of the East Coast, consisting of three eight-wheeled sleeping cars, four ordinary eight-wheeled W. C. J. S. coaches, and two six-wheeled coaches, making up a total approximate weight of 195 tons. Only one engine was used—*Eamont*—a Ramsbottom "Newton" rebuilt as a *Precedent*. Necessarily the time for the first hour was slower than on the previous occasion, with a load so much heavier, but even so the 10¼ miles uphill from passing Watford to passing Berkhamstead were run in 10 minutes 58 seconds, and Tring was passed in 28 minutes 17 seconds from Willesden (26¼ miles), while Rugby (82¼ miles) was passed in 90 minutes 11 seconds from Euston ; Tamworth (110) in 1 hour 59¼ minutes ; Stafford (133¼ miles) in 2 hours 25 minutes 44 seconds ; Crewe being reached in 2 hours 55 minutes 36 seconds. At Crewe, the *Hardwicke*, as before, took up the running, but assisted this time by a pilot, *Princess Royal*, one of the 7 ft. 6 in. singles of the *Problem* class, built more than 30 years ago. Warrington was passed in 26 minutes 20 seconds (24¼ miles), but two slacks—one for

road repairs and the other for signals—caused quite four minutes delay, so Preston was not passed until 58 minutes from Crewe. The distance of 58¼ miles from Preston to Shap summit was run in 71 minutes 49 seconds, and a very steady descent of the subsequent down gradient brought the train to Carlisle in 30 minutes 24 seconds more, the arrival being at 1.41.24, or 2 hours 40 minutes 13 seconds from Crewe.

Two Caledonian engines, Nos. 91 and 78, both 6 ft. 6 in. coupled Drummond bogies, now assumed the lead, and a very striking piece of locomotive work succeeded. The run of 117¾ miles without stop to Stirling was accomplished in 2 hours 4 minutes 59 seconds; Lockerbie (25¾ miles) was passed in 27 minutes 27 seconds; Beattock (39¾), in 40 minutes 26 seconds; Beattock Summit (49¾), in 55 minutes 56 seconds—the lowest speed up the incline of 1 in 75 being 33 miles an hour—and Carstairs (73¾) in 77 minutes 17 seconds. At Stirling the pilot was dropped, and the distance thence to Perth (33 miles) occupied 40 minutes 55 seconds. No. 70 next came on, and ran that heavy load to Forfar (32¼ miles) in 37 minutes 16 seconds, in spite of rain and stormy cross winds; also Forfar to Aberdeen (57¼) in 63¾ minutes against like disadvantages. The train arrived at Aberdeen ticket platform at 6.26, having made the journey of 540 miles from Euston in 10 hours 26 minutes. Of this distance a pilot was used for only 258 miles, the other 282 miles being accomplished with one engine on a load of 195 tons—a very noteworthy record.

It will probably be asked what maximum speeds were found necessary for the performance of this remarkable work. My answer is that in no case was any higher velocity attained than I have noted times without number by the ordinary express trains on the respective lines, nor were my previous recorded maxima either attained or closely approached. The East Coast once touched 80 miles an hour, the West Coast 78; but as a rule the running speed was somewhere about 60 miles an hour, very evenly maintained, and rarely exceeded 70 to 72 miles an hour under the most favorable conditions. The feature of the race, as in that of 1888, has been the maintenance of high velocities for long distances and uphill. When the loads and conditions are compared with those of the race of 1888, it will be recognized that the locomotive work of the present season has been enormously superior. On that occasion very light "specials" were run at average and maximum speeds which have often been equalled by heavier ordinary expresses over particular lengths of the lines, whereas in this case it is the ordinary heavy expresses that have achieved such splendid results.

As to the question of safety of travelling, I may observe that only those who are ignorant of the conditions involved have any doubt on that point. All who understand what is essential to safety and what is actually done recognize that to raise such a doubt at all is absurd. If, then, "racing" expresses are unsafe, so is every decent train that runs, indeed, more so, for in this case special precautions are taken to keep the road clear so as to avoid even the slightest delay.

With regard to the matter of ease in running, my experience is that with these trains—on both routes—as in former instances of fast work, the steadiest running is at the highest velocities. In one case some slight oscillation was set up at 53 miles an hour, and reached its maximum at 57 to 58. When the speed reached 60 the oscillation decreased, and at 65 miles an hour it had ceased altogether. At 70 to 75 miles an hour the steadiness was absolute. At the same time the superiority of "bogie" coaches to six-wheeled stock has been made very apparent, and the lesson will doubtless bear fruit.

As to the engines, it is worthy of note that the 6 ft. 6 in. coupled type performed the entire work on the West Coast—except as regarded occasional pilot assistance—while 7 ft. 7 in. or 8 ft. 1 in. singles did that of the East Coast as far as Edinburgh, with the aid of 7 ft. coupled pilots over the last stage, 6 ft. 6 in. coupled engines then continuing the journey to Aberdeen. Once more is noticeable the remarkable uniformity of excellence in the actual work of widely differing British locomotive types.

It may be worth while to add that several "record" trips with light loads were made on the West Coast route with five coaches. Aberdeen was reached on three successive days at 6.14, 6.5 and 5.59 A.M. by the trains which left Euston at 8 P.M.—that is to say, in 10 hours 14 minutes, 10 hours 5 minutes and 9 hours 59 minutes respectively. These are brilliant achievements, though, of course, as specimens of locomotive work they bear no comparison with that accomplished with heavy loads, as set forth in the preceding notes.

That it is quite feasible to run with a light load from Euston to Carlisle at the average rate of 60 miles an hour has already been demonstrated, probably the remainder of the journey could be completed at a like rate. The East Coast train, were it equally light, could assuredly go to Edinburgh at the same speed. But I doubt the feasibleness of any material acceleration north of Edinburgh under existing conditions.

Whatever may be the outcome of this curious rivalry, no one will deny that the achievements of the competing lines constitute a fresh and brilliant epoch in railway history.—*The Engineer*.

Since the above letter was published in *The Engineer* a dispatch from London announces that a West Coast train, which left Euston Station at 8 o'clock on the evening of August 20, arrived at Aberdeen at 4.58 the following morning, making a running time of 538 minutes, which is, we believe, the shortest time on record for a long run. This is a fraction over 60 miles an hour for the whole distance, including stops, so that when the delays for slowing down, station stops and changing engines are made it will undoubtedly be found that the actual speed attained will be close upon 80 miles an hour, if these figures are not actually exceeded. Heretofore the Empire State Express of the New York Central & Hudson River Railroad has been the fastest long-distance train in the world. Its running time from New York to Buffalo, a distance of 440 miles, is scheduled at 520 minutes, of which the time-table shows a loss of seven minutes, three at Albany and four at Rochester, with additional stops at Utica and Syracuse. Making no allowance for stops, the average running time is 50.77 miles an hour. If such an allowance is made the average running speed is raised to 52.36 miles an hour. In making this comparison between the American and the English train, it must be remembered that the time of the Empire State Express is one that is made day in and day out for the whole year, irrespective of the weather, the condition of the rails and other variables that may tend to retard the speed of a fast train. If the West Coast Line puts on a regular train to do this work throughout the whole year and then maintains its schedule with the train on time, it will be an achievement of no mean magnitude. In the interests of possible locomotive work, it is to be hoped that this will be done, and that the rival roads will not be tired out with their efforts—as they apparently were in 1888—and be content to show what they can do at a spurt, and then tacitly acknowledge that they do not care to put forth the effort to maintain the pace. But, weather conditions excepted, there seems to be no good reason why, if the engines are maintained in perfect working order, what has been done on these racing runs cannot be kept up as a part of the regular working of the road.

LOCOMOTIVE PISTON-RODS.

THE designer starts with a 3-in. rod (7 sq. in., say, sectional area), and then thinks he must, by hook or crook, get his 7 sq. in. net section through the cotter-hole as well—*i.e.*, he thinks that nothing less is strong enough, whereas if we were to take any engine at random and find the body of rod had 7 sq. in. and the cone 5¼, instead of worrying ourselves about the latter not being strong enough, we could safely reduce the former down to 5¼, provided we retained the same moment of inertia by making it hollow; in fact, if the engine could suddenly be converted into a single-acting (tensional) engine, we might at once put in a solid rod of 5¼ sq. in. section. There certainly seems something very truistic about this; but consider an average man getting out a new motion; say 3-in. rods have always been used, but with solid crossheads, and that now it be proposed to put on loose cottered ones; starting them with a 3-in. rod, he proceeds straightway to make his coned end of the same section as the rod itself, a bit of superficial reasoning resulting from having confined his attention merely to the question of strength; assuming then this desire on his part for equal strength, he has forgotten (1) that the rod may be ultimately turned down to 2¾ in. before scrapping; he thus assumes a rod 20 per cent. stronger than in reality (and, although irrelevant to this argument, 30 per cent. stronger against buckling), for this 2¾ in. *is* the virtual size of the rod; (2) that the rod, being a hinged strut, requires to be stronger in the body than in the cone; for if the latter is well fitted up, it is only subject to direct stress, and therefore is stronger proportionally than the body, as the stress is not distributed uniformly over the latter's section, owing to flexure. What I am driving at is this: He wants to get his coned part strong enough for the job, and to that end makes it equal to the 3-in. section, whereas, for the two reasons above, he should *not* take 3 in. as his basis.

As far as strength goes, it is absurd to worry about making the coned end equal to the body, especially the original size of the latter. Given a certain diameter of rod as suitable for a given engine, we can safely turn the end down for the required cone, and rest assured that it is *per se* quite strong enough for its work. But the mischief (theoretically, at least) occurs directly we couple it on to a stronger section than itself, because all the stretch will come on the weaker one; it is not

likely that a 7-in. section is going to do much stretching when there is a 5-in. one conveniently contiguous.

Of course *this* is the real point to be borne in mind, and the designer of a swelled end, who put this forward, would be showing just cause; but I fancy it is generally lost sight of; in fact, they consider the matter of strength and ignore that of elasticity; in a word, if I *were* to enlarge an end it would not be that I wanted to make the end as strong as the body, but that I did not want the body *to be stronger* than the end; there is a distinction here *with* a difference.

It is, of course, a very elementary fact that it is desirable to retain a uniform section throughout, so as to distribute the "stretch" equally all through. And this would lead us to entertain the idea that it would be of advantage to elongate the cotter hole—that is, give it 1 in. or 1½ in. "draw" instead of the usual ½ in.; it would undoubtedly be all the better for it; the only objection that I can see is that we should not get so tight a conical fit, as the sides of the cone would yield. As to elongating the hole, I merely mention it for what it is worth; but if I ever *were* troubled with rod-end failures, I should look first to the material and workmanship, and *then*, rather than enlarge the end, should try the efficacy of lengthening the cotter-hole, bringing it up to the mouth of the crosshead.

The best way would be to drill out the piece next to the crosshead first, giving it about $\frac{1}{16}$ in. taper; plug up fairly tight (riveting over slightly on bottom side), and then traverse out the cotter-hole. We should then, when fitting in, get a solid resistance to the compressive reaction of the crosshead, and at the same time get a longer reduced section to take up the stretch; at any rate, I should be inclined to do something of this kind before falling back on the good old time-honored "If it breaks, make it bigger" doctrine, which, I fancy, has done yeoman service in its time. The extra shilling or two cost would be well laid out, I think. I have often wondered to what extent the expression "interchangeability of parts" is taken literally; I believe a good many non practical engineers do accept it as being literally true. Well, no fitter, I should think, would dream of taking a little or big end brass, or an axle brass, out of one engine, and putting up in a sister one without a preliminary try on; much less, indeed, should he think of changing a crosshead cotter without trial; and if he does try over the cotter, it is no use smashing it down for all he is worth, and then drawing and serenely examining it, although it will be lucky to get even this attention; the proper thing is to emery-paper the edges and knock in lightly, just enough to mark it; if it shows a fit all through, you may then bang it down with a light heart.

If the cotter were $\frac{1}{32}$ in. out in its length (that is, if, instead of a taper of ½ in., it has ½ in. ± $\frac{1}{32}$ in.), it might make a fit for itself with a lot of persuasion—that is, plenty of driving down, but it will be at the expense of the fibres of the rod-end, top or bottom as may be; but if, when allowed to go, there is still a space of $\frac{1}{64}$ in., say, at the bottom end; then it will work in the hole, and that $\frac{1}{64}$ in. will very soon take unto itself another $\frac{1}{64}$ in., and the last state of that cotter will be worse than the first; in short, you will find the edge of the bottom half grooved, and pretty well intact on the top half where there has not been the fore-and-aft knock in the hole. In anticipation of certain probable criticisms, I may ask of what use *are* designs unless properly carried out—that is, fitted up properly? It is one thing, sir, and so easy, too, to show on paper a cotter having a mathematical fit in the hole, and quite another thing to attain it. So you see that, after all, success *does* ultimately rest with the workman. You may say that minute instructions of this nature are not expected to be shown on a drawing; that a draftsman is not supposed to tell a fitter his business; no, and for a very good reason, too, generally speaking. I often call to mind what a pupil once remarked to me when together in the shops. The question arose as to whether it was desirable, or necessary, for the heavily premiumed ones to attain any greater degree of manipulative skill at the vise. He argued that it was not necessary for them to be able to *do* a job, but only to know how it was done. Well, it does not take workmen long to know their man. To go back a bit, I think with a detail like this (*i.e.*, a piston-rod), which is a rather fruitful source of failure, one cannot take *too* great pains. It is one thing to fit a brass in an axle-box, and another to cotter up a crosshead. This is, therefore, a detail that shed fitters ought to receive a gentle reminder to be careful with. We know that a good many of their jobs are done in a rush; anybody who has been on the repairs bench (on connecting-rods, say), knows that a lot of his work is due to shed-fitting.

I was once looking at an engine in a certain station, and noticed that the crosshead cotters had ½-in. draw; the hole in the top of the crosshead was about 2¼ in. long, and the cotter only 2 in. Well, it was very certain she had not been designed like that; $\frac{1}{16}$ in. would be ample. Either the crosshead or the rod had been changed, and I should have concluded that the rod end had proved too big for the hole, and so only able to take the 2-in. cotter; but as I could not see any shoulder standing out from the crosshead, I knew that the end had gone right up, and it was therefore the cotter-hole that had been set back too far from the end of the rod, so that the original size cotter would not enter. There was, of course, the chance that the rod and cotter were right and the crosshead at fault, so I made it a point to look out for others of the same class, and I found their cotters were about 2½ in. wide, so those I first saw were about 20 per cent. below their proper strength. As a matter of detail, it was not at all likely to be the crosshead that was wrong, because we can very safely assume that if it *were* so, it was not the original one off any of the same class, but a renewal, and crossheads do not fail so as to require replacing *every* day; whereas it is a very common event to put new ends on rods, when they are iron at least; and I can *quite* imagine instruction being thoughtlessly given to set the cotter hole back a bit from the end, so as to leave more metal there—that is, supposing this to have been the point of failure. I was once told of an official, drawing his $3,000 a year, who gave orders to put a blast pipe in a certain engine 4½ in. *full;* if he would do that, he would do the other.

As to the cotters alluded to above, you may or may not expect to get scientific engineers for $1.50 a day, although, of course, there was absolutely no excuse whatever in this case, for, leaving the crosshead out of the question, the fitter could have seen that the cotter did not tally with the rod. But this engine remained like it for some months to my knowledge, and so people who were drawing one or two $1.50 daily from a grateful company had had time to see it.

It did not fail then? Oh, no; not as far as I know. But that is no argument; I dare say we might go round to a good many bridges and other structures to-morrow and abstract half the metal (or I had better say half the strength), and still they would stand and do their work, too; but it is *usually* thought advisable to make such things 400 or 500 per cent. stronger than the bare failing strength. I *have* known, though, of a brass gear (of all things) working up to a stress of 14 tons per square inch; that was only the static load, either; considering that there was no compensating gear, and the sometimes sudden application of full pressure, I do not fancy there was much margin of safety *there*. I expect it was got out "by the eye"

Tail-Rods—I am in favor of these caudal appendages, but object to their weight. It certainly seems extraordinary that makers should put in solid ones if they are alive to the importance of light reciprocating parts. "Novoye Vremya" said he had tried tubular ones, but had had trouble with them. We could see what section we required, and add on, say, $\frac{3}{8}$ in. to the diameter, to allow for truing up; tubes can be got thickened at the ends either inside or out; and we should use a fine thread. The tube could be either pinned on, or sweated, or both. Or you could leave the rod end long (about the same length as shown screwed) and weld the tube on; this answers all right for some of Joy's valve gear rods; and Stroudley did it with his pump rams; and they had severe axial stress to put up with which these tail-rods would not be subject to. Taking a piston head, rings, and nut with the liberal weight of 160 lbs., and finding the maximum bending moment, allowing for partial weight of piston and tail-rods, and regarding them as only "supported," I find that an iron tube 2¼ in. external diameter and ⅛ in. thick would do; say 2½ in. external to begin with; that allows ⅛ in. a side for turning down; an amount that would see out the lifetime of a good many engines one could mention; and, as far as calculations go, the deflection would be insignificant. Taking the tail-rod as 32 in. long, and allowing for the solid part common to both designs, the weights would be roughly 15 lbs. and 40 lbs.—a saving of 62½ per cent. in the weight. The pin should be well up to the back end of the tube; it is as well to keep it away from the packing, with an eye to future fitting, in case it is ever unshipped.

The small side of the pin-hole can be countersunk nearly the whole thickness of the tube (about one-eighth larger at the mouth) and riveted over; the pin will then hold, however the rod be turned down. I have set the pin horizontal, affecting the strength least in that position; as to the piston nut pin, it does not matter how that is put, though they are usually all made to stand one way, for sake of appearance. Talking of appearance, some people set their crosshead cotters with the front edge at right angles to the axis of rod; others set the back edge so; I do not think there is much in it, whichever you do; and it most decidedly looks better to set the cotter itself square with the rod. In favor of putting the front edge square you could certainly argue that it gives same resistance of crosshead top and bottom in front of the cotter; it most cer-

tainly looks better than when set the other way, which gives the maximum difference in this respect—that is, with cotter of 1 in 16 taper, and 6 in. diameter of crosshead, we should have, say, 1⅞ in. in front of cotter and 1⅝ in. at back. As I have it, there is half this difference. What *is* in their minds is some idea, I suppose, of extra security against the cotter working back—that is, when the split cotter hole is knocked right through. One thing is very certain—you ought to have a small taper on the cotter, as it will soon knock through and lose the support of the split cotter; and yet, on the other hand, the smaller the taper the sooner the cotter *will* knock through; they might have a double row of split-pin holes 1 in. apart horizontally, set hit-and-miss, say, 1 in. or more up the cotter, if they prefer this to a long split cotter hole; at any rate, you ought to obviate any likelihood of the main cotter being able to slack back when knocked through ½ in. or more, although I have seen the split cotter through a clear 1 in. many a time. But the main cotter had only 1 in 96 taper on each side, so it was pretty secure, and things are all right while they *are* all right. But no one would like to let a connecting-rod cotter go without its set screws, which are really *the* sheet anchor (for all the good split pins and cotters are for such purposes, they might as well be left out). Why, then, run the risk of the crosshead cotter being in same condition?

Thrust of Piston Opening Crosshead.—This could easily be experimented upon. Cotter up a rod and apply a 20-ton thrust and see how much the rod moves up into the crosshead, either by direct measurement or by observation of the cotter. A very slight inward movement of the rod would be apparent to the man who had cottered it up, either by the way he could drive the cotter a bit more, or else draw it out. This gauging, however, is not quantitative, and perhaps would not be accepted as proof. But we could cotter up and then hang a few hundred weights on to the cotter, and then apply the thrust; if we had, say, a 1 in 25 cotter, a movement of $\frac{1}{200}$ in. would drop the cotter ⅛ in. If the pressure were put on quietly and *all jerks obviated*, there could be no doubt as to the crosshead having fairly yielded. However, as I said before, one can easily satisfy himself in any specific case (of actual working) by drawing the cotter and examining the edges.

Valve Spindle Sockets.—There ought to be a taper pin hole at back end of socket, for the purpose of starting the spindle when disconnecting; the pin would be about ¼ in. and $\frac{5}{16}$ in.; it is very seldom adopted, but it ought to be; if it is not there, the socket will have to suffer.

In connection with drawing out the rod, there is one point that might advantageously be looked after; when turning up an old rod, I should ease the end a bit where it does not enter the packing; the parallel part I mean; the turner could easily note the length of the unworn part and give it a good easing, the last thing; the shed men would hold his name blessed when next taking it down, especially if much worn and with *some* metallic packings. I have seen valuable hours wasted getting out valve spindles that had worn a lot; of course they had been turned up scrupulously parallel all along, and being from $\frac{1}{32}$ in. to $\frac{1}{16}$ in. bigger than the middle of the rod (through wear), wanted a lot of drawing. This is such an easy thing to rectify, and yet it is sure to be scoffed at.

I must own that I should be very careful about giving orders for this, if using screwed ends, because I should most decidedly have them bear on a shoulder, as in Vauclain's; well, toward the end of a rod's career there would not be much bearing surface on this shoulder, and a turner might take *too* much off the end of the rod; the only thing would be to limit him, say, to never getting below a bare $\frac{1}{16}$ in. of shoulder. With cottered ends you c n leave him alone, he cannot do any harm (at least he must not encroach on the conical fit), and if there *is* a shoulder—well, all I can say is, it ought not to have a bearing on the crosshead.

Turning Down Rods for Wear.—I gave ½ in. a side as a maximum, a very liberal allowance too; an amount that would, with average rate of wear, last out most engines. As to prolonging the cone into the rod, I would suggest this for renewals of existing engines where they admit of it; in getting out a new one, I should grudge any more clearance than actually necessary, say ½ in. between the face of the crosshead and the ends of the gland studs; any more than this is only unduly robbing the connecting-rod. It is a question, though, if it would not be worth while in the case of solid crossheads or enlarged ends (especially when the latter accompany *some* arrangements of metallic packing) to make this clearance sufficient to enable you to get at the rings without unshipping the piston, in the former case, or drawing the rod through in the latter.

Material for Rods.—I am not particularly in love with very high steels for this purpose, for, with end failures, in the absence of electrical welding plant, the rods would be scrapped. I know of one line that uses about 32-ton steel for their piston-rods; they have a solid crosshead (a forked end, that is), and are therefore expensive rods, yet they are always thrown away for defective ends. Any good smith would undertake to shut an end on such a rod and answer for it. It has often seemed to me that iron rods wear as well, if not better, than steel ones. We might use cold rolled iron and get a few tons extra strength, but we should lose it the first time we put the rod in the fire.

Screwed Ends.—"Novoye Vremya" talks of these breaking short off. I have known scores have the nuts stripped right off, but not the rods break. These averaged 32-ton steel, and the screwed ends were V-thread, seven per inch, 3 in. in diameter over all and 3 in. long; the body of the rod was 2¾ in., thus securing, I suppose, what he wishes; on the other hand, all Webb's are much smaller than the body of rod, as are also Vauclain's, and I never saw one fail. This striving after a hard-and-fast uniformity of sectional area is all very well in its way, but, like many other things, you can overdo it. (I need scarcely say that it is *the* correct thing.) However, if I were designing a crosshead like Webb's, I should most certainly not entail the disadvantages of a swelled end, to gain what your correspondent desires; I should keep the rod flush right along, so as to draw out without interfering with the packing and avoid split glands and bushes; but at the same time I should most certainly put a shoulder on the rod to bear upon the crosshead.

I may as well sum up the points I have insisted on in this letter; (1) and (2) apply to cottered ends only:

1. Insure contact between the end of the rod and the inside of the crosshead at the back end, and see that it bears, if anything, on the outside of the annulus, as there the crosshead is stiffest.

2. Where there is a shoulder on the rod, keep it *off* the face of crosshead. It is a question, though, if it would not be worth while in the case of solid crossheads or enlarged ends (especially when the latter accompany *some* arrangements of metallic packing) to make this clearance sufficient to enable you to get at the rings without unshipping the piston in the former case or drawing the rod through in the latter.

3. With a rod that passes through the crosshead and takes a nut at the far side, *by all means* have a shoulder to bear on the crosshead; this shoulder to have quite ½ in. radius.

4. Insure a good job to begin with, especially with a cottered end, and try and have due care exercised in the shed when changing crossheads or rods, to see that the conical fit is all right, and that the cotter is a correct (not merely tight) fit.

5. In the case of *all* pistons, see that there is a collar on the rod to bear up on the piston head. Where the heads are never taken off, secure by a pin. There is nothing to be gained by making a huge hole right through nut and rod. If the head has to be removed for piston examining, or when disconnecting (as in Stroudley's rods), put a pin at the back of the nut, and give it about $\frac{1}{16}$ in. draw in the hole, so as always to keep it up to the nut, for although the piston may not move up further every time, which it *will not* do if the rod has a collar, still the nut will go round a bit further, and if the hole is through the nut it is a nuisance.

Given good material and the observance of these points, I think rod failures ought to become in future conspicuous by their absence.—*Engineering.*

NOTES.

Bicycles are said to have seriously affected the sale of pianos in England. The reason given is that when a girl is asked to choose between the two for a present, she invariably selects the wheel.

The Los Angeles Electric Company, Los Angeles, Cal., use "Stevedore" transmission rope for their drive, and have recently ordered 3,000 ft. for this purpose from the C. W. Hunt Company, New York City, who are the sole manufacturers.

The Gould Coupler Company report that the recent fire in their works at Buffalo, N. Y., was at the forge plant, and had nothing whatever to do with the coupler works. They are now turning out between 500 and 600 couplers a day, and can ship all orders promptly. The forge plant will be running again about October 1.

Lubricating Pulley Block.—At some service tests of hoisting recently made by Robert Grimshaw and Lieutenant John A. Bell at the Brooklyn Navy Yard, it was shown that, when the blocks were lubricated with waterproof graphite grease made by the Joseph Dixon Crucible Company, of Jersey City, a saving of from 30 per cent. to 35 per cent. was effected in the power over that required by unlubricated blocks.

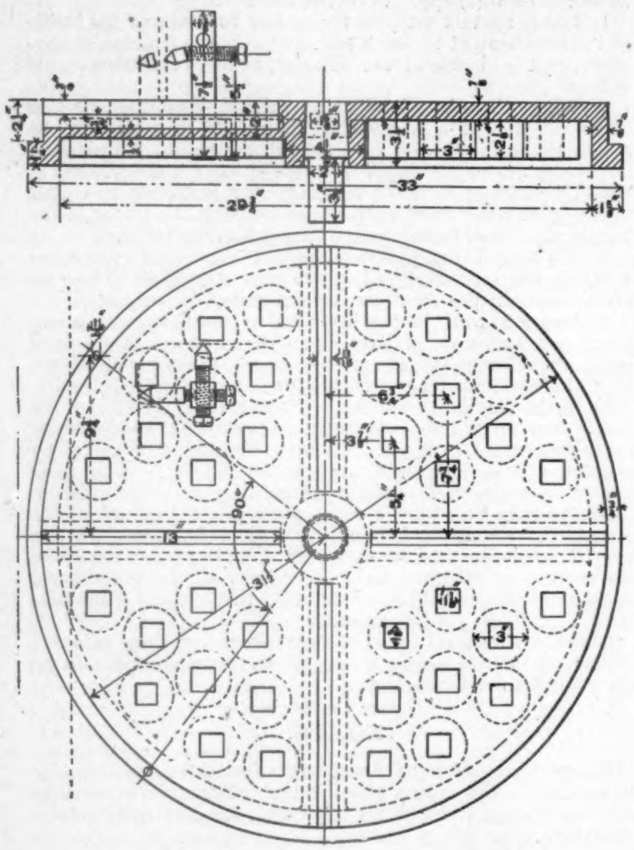
André's Proposed North Pole Balloon Expedition.—A correspondent in Sweden writes us that Mr. Nobel has raised

his contribution to this expedition to 65,000 kroner ($18,000), providing the remaining 65,000 needed for the expedition will be guaranteed by others within two months. It seems probable therefore that this daring expedition may be undertaken before long.

The Largest Sailing Ship Afloat has recently been completed at Bremen. She is called the *Potosi*, is a five-master, 394 ft. long, 50 broad, with a draft of 25 ft., and a carrying capacity of 6,150 tons.

The Abendroth & Root Manufacturing Company, 28 Cliff Street, New York City, manufacturers of the improved Root water-tube boiler, have been awarded the 626 H.P. boiler contract from the Union Car Company, of Buffalo, N. Y., and a 500 H.P. contract from the Reading Steam Heat & Power Company, of Reading, Pa. They are also erecting in New York City 300 H.P. in the College of Physicians and Surgeons, two boilers in the Baptist Home, one boiler in the Parmly Building, and two boilers for the Sing Sing Electric Lighting Company.

A Planer Chuck for Steam-Chests.—There is a handy wrinkle in use in the shops of the Philadelphia & Reading Railroad, at Reading, for holding steam-chests upon the planer while they are being finished. The chuck consists of a circular table, as shown, having a central bearing pin 2 in. in diameter, upon which the device turns. The top face is plentifully supplied with holes for holding the dogs, so that any size of chest can be readily held. The dogs are of the shape shown



A PLANER CHUCK FOR STEAM-CHESTS.

in plan and elevation, and grip the chest at the corners. Two ½-in. pin-holes standing at an angle of 90° with each other, as shown on the plan, serve to hold the table in position. After one side is planed the table is swung through 90°, the holding pin inserted through the other hole, and the chest thus brought into accurate alignment for doing the work upon the other side.

The Willans Central-valve Single-acting Engines made a conquest in London, and are employed for direct driving in a majority of the electric stations there. The evolution of the engine began about 1870 under the constant and able efforts of Mr. Willans, who was a competent steam engineer at the beginning, and an authority on the subject at the time of his death about three years ago. Now has began a struggle between the single-acting and the turbine engines made at Gateshead by Mr. Parsons, and we may also include the De Laval engine, which, however, does not seem to be made in England at this time. This race of motors for dynamo driving is one of much interest, and in London is no doubt typical of what is to follow elsewhere. In this country the horizontal automatic engines have held a large place for direct driving, but are slowly yielding to the vertical or inverted type.—*Industry.*

RAILWAY ROLLING-STOCK.

In a paper read recently before the Institution of Civil Engineers in England, Mr. Alfred John Hill gave some data regarding the wear and durability of railway rolling-stock in that country which will be of interest to our readers as a basis of comparison with the results obtained in the United States.

Boilers.—There is no doubt that the more perfect the condition in which a locomotive is kept, the more efficiently and economically it can do its work; and there is probably no part of a locomotive which requires more attention, or which so assuredly repays for that attention, than the boiler. In the author's opinion an engine will generally outlast two boilers, and every boiler two fire-boxes.

Lap-welded basic-steel tubes, with 6 in. of brass brazed on at the fire-box end, have been almost exclusively used of late on the Great Eastern Railway. They are as a rule 1⅝ in. in outside diameter, being secured by steel ferrules at the fire-box end and expanded at the smoke-box end. Tubes of steel throughout have been adopted by other railway companies. They have been tried on the Great Eastern Railway, but considerable difficulty has been experienced in keeping them tight, whereas the brass-ended steel tubes have given practically no trouble. Owing to the difficulty of tracing tubes after they have been taken out for repairs, definite information as to their life cannot be given.

Every crank-axle on the Great Eastern Railway, after it has run 250,000 miles, is subjected to a special examination, for which purpose all incumbrances except wheels and crank-hoops are removed, all paint is scraped off, and the axle is thoroughly cleansed with spirits. A similar examination is made after every additional 100,000 miles has been run. All axles, whether crank or straight, are also specially watched while being turned, and none are used where the slightest flaw is visible. During the year 1892, 36 crank-axles were, for various causes, condemned on this railway, their average service being about 275,000 miles. In two cases the axles failed while running, but caused no accident to the trains. In 13 cases flaws were discovered in the shops or running sheds. The remaining 21 crank-axles belonged to engines which were either condemned or were being rebuilt with axles of a standard design, but were themselves perfectly sound, the average mileage run by them being 292,619 miles.

Tires.—The life of tires must depend greatly upon the nature of the road, as well as upon the description of the traffic worked and the design of the engine. Unfortunately, in deciding upon the section of rail to be used, engineers do not always sufficiently consider the wearing effect which a comparatively sharp-cornered rail has upon the tires. On one line with which the author is acquainted the flanges of the tires wear so rapidly that it is often necessary to re-turn the tire before it is appreciably worn upon the tread; and upward of ¼ in. is sometimes turned off the tread in order to bring the flange to its correct form. In considering this question it must be remembered that, in addition to the cost of the tires themselves and of the work entailed in lifting the engine and turning the tires, etc., the engine is for the time thrown out of service. The tires in general use on the Great Eastern Railway are made of Bessemer steel, having a tensile strength of 40 tons per square inch, and composition shown by the following chemical analysis:

	Per Cent.
Combined carbon	0.350
Silicon	0.083
Sulphur	0.064
Phosphorus	0.047
Manganese	0.605
Iron (by difference)	98.851
	100.000

With a view to increase the life of tires, and also to decrease the proportion of material which is finally discarded, in comparison with that which is actually worn away, it is desirable that new tires should be made as thick on the tread as can be conveniently arranged consistently with the simple design of spring gear, etc. The tender tires on the Great Eastern Railway have therefore recently been made 3¼ in. thick, those for the engines being 3 in. thick on the tread. No engine or tender tires are allowed to run when reduced to less than 1⅜ in. in thickness. If, however, when they come into the shop to be turned, it is found that the flange cannot be brought to the right section and leave the tires 1½ in. thick, they are condemned. Engine and tender tires may as a rule therefore be considered to be worn out when they are only 1½ in. thick.

The average mileage of 10 sets of four wheels-coupled express-engine tires on the Great Eastern Railway was found to be as follows :

	Leading.	Driving.	Trailing.
Mileage	121,351	194,339	194,339
Miles per $\frac{1}{32}$" reduction in thickness	2,528	4,049	4,049
Loaded weight on wheels	Tons. Cwt. Qrs. 14 8 2	Tons. Cwt. Qrs. 14 1 0	Tons. Cwt. Qrs. 13 10 3
Diameter of wheel on tread	Ft. 4	Ft. 7	Ft. 7

The average mileage of 10 sets of six wheels-coupled goods-engine tires was found to be as follows :

	Leading.	Driving.	Trailing.
Mileage	168,012	168,012	168.012
Miles per $\frac{1}{32}$" reduction in thickness	3,500	3,500	3,500
Loaded weight on wheels	Tons. Cwt. Qrs. 12 8 0	Tons. Cwt Qrs. 14 0 0	Tons. Cwt. Qrs. 10 2 0
Diameter of wheel on tread	Ft. Ins. 4 10	Ft. Ins. 4 10	Ft. Ins. 4 10

The average mileage of eight sets of six-wheels-coupled suburban passenger tank engine tires was found to be as follows :

	Leading.	Driving.	Trailing.
Mileage	105,444	105,444	105,444
Miles per $\frac{1}{32}$" reduction in thickness	2,197	2,197	2,197
Loaded weight on wheels	Tons. Cwt. Qrs. 12 17 1	Tons. Cwt. Qrs. 13 13 0	Tons. Cwt. Qrs. 13 19 3
Diameter of wheel on tread	Ft. 4	Ft. 4	Ft. 4

The average mileage of six sets of tires on six-wheels-coupled tank-engines similar to the above but used for goods trains, and not fitted with the Westinghouse brake, was found to be as follows :

	Leading.	Driving.	Trailing.
Mileage	216,090	216,090	216,090
Miles per $\frac{1}{32}$" reduction in thickness	4,502	4,502	4,502
Loaded weight on wheels	Tons. Cwt. Qrs. 12 4 2	Tons. Cwt. Qrs. 13 4 2	Tons. Cwt. Qrs. 13 5 2
Diameter of wheel on tread	Ft. 4	Ft. 4	Ft. 4

It will be noticed that the tires of the latter engines ran more than twice the mileage of those of similar engines used for passenger trains. This is no doubt due to the action of the continuous brake, and to the fact that these passenger engines work to a large extent on the Enfield Branch, one of the hardest services on the Great Eastern Railway, where they have to run 10¾ miles with 14 intermediate stops in 40 minutes. Seventeen of these passenger tank engines were fitted in January, 1892, with special hard steel tires having a tensile strength of 48 tons to the square inch, and the results obtained up to their first turning were satisfactory. The average mileage was 47,134 for an amount of wear equal to ¼ in. in thickness, or 5,892 miles per $\frac{1}{32}$-in. reduction. This is nearly three times the duty obtained from the softer tires.

Sixteen pairs of crucible-steel tires have been tried on the driving and trailing wheels of the four-coupled express engine. Only one set had worn out by March 31, 1893, and these had run 202,623 miles. The average mileage per $\frac{1}{32}$-in. reduction in thickness for the 16 pairs up to March 31, 1893, was 4,715 miles compared with 4,049 miles for the softer tires previously referred to. During the three years 1888–90 the consumption of engine and tender tires for repairs and renewals on the Great Eastern Railway was 3,512, weighing 1,407 tons 8 cwt. ; and the engine-miles run (excluding those by "capital" engines) were 58,202,648. This is equivalent to a consumption of 54 lbs. of tire for every 1,000 engine miles ; or taking the average cost of new tires at £10 per ton, and allowing for the credits obtained by the sale of old tires, the cost of engine and tender tires per 1,000 engine miles was about 4*s*. 4*d*., or 0.052*d*. per mile.

A RIDE ON A DEAN COMPOUND.

MOST of our readers are aware that the late J. N. Lauder a few years ago built a compound locomotive of the American type from designs made by Mr. F. W. Dean. After Mr. Lauder's death, and he was succeeded by Mr. Henney as Superintendent of Machinery of the whole New York, New Haven & Hartford Railroad system, the question came up with reference to the merits of compound locomotives generally, and this one particularly. It was then decided to make a practical test of the engine referred to by running one of the trains on the Old Colony Division with it for a month, and then putting one of Mr. Lauder's simple engines on the same run for the same length of time. The run was from Boston to Wood's Holl, a distance of 71¾ miles. The trains consist of about eight cars, and the number of stops are sufficient to make the service a very fair test of the capacity of the locomotives.

While in Boston a few weeks ago, through an invitation from Mr. Dean, we had the privilege of a ride on his engine from Wood's Holl to Boston. The test is under the charge of Mr. Boyden, a son of the former Superintendent of Motive Power of the New York & New England Railroad. No results have yet been reached, and of course a comparison will be impossible until the simple engine has been tested. All that can be done now is to comment on the working of the engine, which is very satisfactory. There is no difficulty whatever in starting, and the absence of a violent exhaust even when working hard is noticeable. The results of the test will be awaited with interest. The only unfavorable comment to be made is that the engine "rides hard." Under certain conditions of working, every revolution of the driving-wheels can be felt in the cab, and is apparently due to the action of the counterbalance, and, if so, should be remediable. The working of the engine is otherwise very satisfactory, and if the anticipated economies are realized will do much to bring this form of compound into favor.

DEATH OF EDWARD F. C. DAVIS, PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.*

PROBABLY before this number of the AMERICAN ENGINEER reaches its readers most of them will have learned through the daily papers of the sad death of Mr. Davis, who was killed in Central Park, New York, while riding horseback, on the evening of August 6. When found he was unconscious, and the

EDWARD F. C. DAVIS.

supposition is that his horse became unmanageable and fell on him.

Mr. Davis was born in Chestertown, Md., on August 13, 1847, and was thus nearly 48 years old. He was educated at and graduated from Washington College, Maryland, in 1866. His business career was commenced in the shops and drawing-

* We are indebted to the *Iron Age* for the portrait accompanying this notice.

room of the Philadelphia Hydraulic Works of Brinton & Henderson. Later he was employed as draftsman at the New Castle Machine Works, New Castle, Del.; Atlantic Dock Iron Works, Brooklyn; Athens Brothers' Rolling Mill, Pottsville, Pa.; and the Colliery Iron Works, Pottsville, Pa. In March, 1878, Mr. Davis made an engagement with the Philadelphia & Reading Coal & Iron Company as Principal Draftsman, and later became Superintendent, and had charge of the shops where all the machinery of their extensive collieries was built and repaired. In 1890 he became Manager of the Richmond Locomotive & Machine Works, and left them in the spring of the present year to take charge of the works of the C. W. Hunt Company, which are on Staten Island, near New York.

Mr. Davis became a member of the American Society of Mechanical Engineers in 1881, and always took a lively interest in its affairs, and was frequently a contributor to its proceedings. From 1891-93 he was one of the vice-presidents, and was elected to the presidency at the annual meeting last fall. He took a deep interest in the affairs of the Society, and always presided over its meetings with great dignity and attracted to himself the members by the charm of his manner and the clear comprehension of all matters brought to his attention. He was very quick of apprehension and prompt in deciding matters on which he was called upon to act. He would not be regarded as a person having an inventive turn of mind, but merely as one with much executive ability and capacity of selecting right things, right ways, and right times for doing what had to be done.

He left a wife and four children, who were in Richmond at the time of his death. The burial was at Pottsville, Pa., where the funeral was attended by many of his old friends, associates and employers, and by a number of members of the Society of which he was the honored president.

PROCEEDINGS OF SOCIETIES.

The Blacksmiths' Association.—The National Railroad Master Blacksmiths' Association, or the N. R. M. B. A., as it is designated, will hold its annual meeting in Cleveland, O., on September 3. In the call for the meeting the Secretary says:

"Our object is to acquaint each other with a multitude of valuable experiences wherein each assimilates from all. Emulation is stimulated, range of knowledge broadened, secretiveness and self-exaltation become abashed. To some people the chief purpose of the N. R. M. B. A. seems to be the reading and printing of papers. While this may be one of the features, and of the greatest good to non-attendants, it is but the focusing of all minds for mutual edification and instruction. The printed record is for reference only."

An International Institute of Engineers and Architects.—Elmer L. Corthell, C.E., of 71 Broadway, New York, late Chairman of the General Committee of the Engineering Congress, has issued a proposition for the organization of an International Institute of Engineers and Architects.

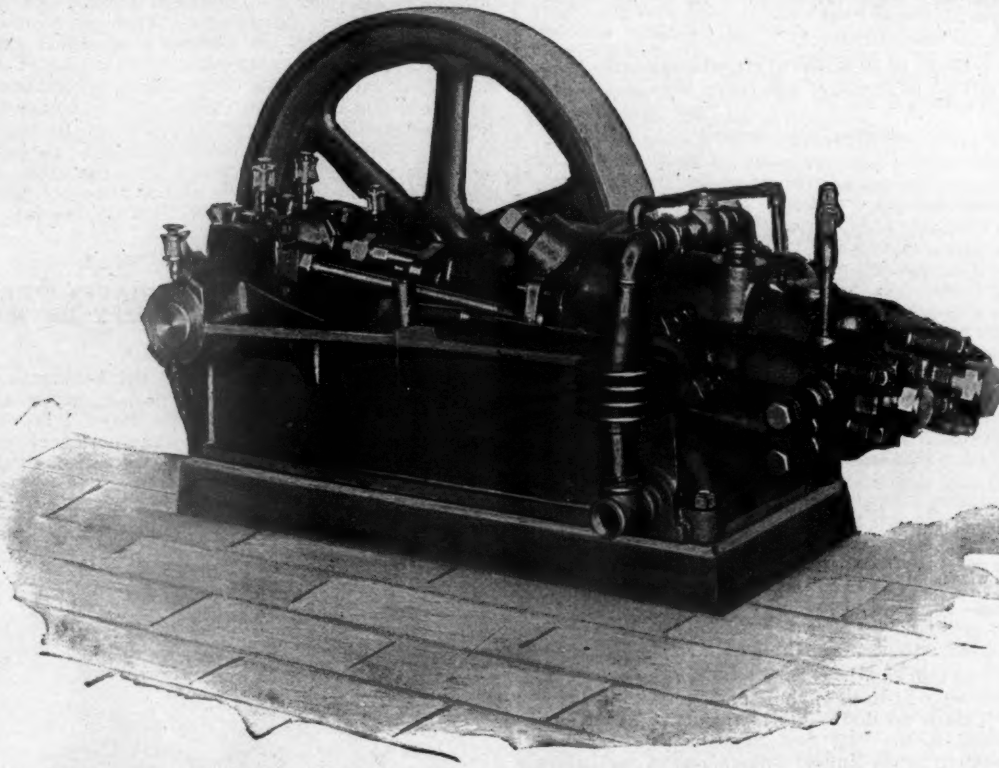
The principal objects of establishing this Institute are:

1. To unite in closer relations all departments of engineering and architecture.

2. To furnish a suitable and convenient channel by which information relating to new discoveries, processes, methods, inventions, and works may pass from one country to all other civilized countries of the world for the benefit of the profession and of mankind.

3. To conduct, by the assistance of the Fellows of the Institute, individuals, and governments, systematic and thorough tests of all classes of materials used in constructive work, and to disseminate through the channel of the Institute the resulting information.

An elaborate organization is proposed for the accomplishment of these objects, which is fully described in the circulars, copies of which will be furnished by Mr. Corthell on application.



THE NORWALK COMPRESSOR FOR HYDROGEN GAS.

Manufactures.

COMPRESSOR FOR HYDROGEN GAS.

We have published frequent notes and a full description of Captain Glassford's experiments with war balloons for the United States Government.

We have, however, never before been able to publish a photograph of the hydrogen gas compressor used to reduce the gas to the necessarily small volume required for transportation.

Heretofore in the countries which have given most attention to ballooning, the operations have been largely confined to captive balloons sent up from places where there were permanent means for producing gas. Armies on the march and in the field have been unable to carry the cumbersome and heavy apparatus necessary for generating the gas on the spot. Now, however, that steel tanks filled with hydrogen under pressure are available, there is no reason why the entire outfit necessary for operating a balloon should not be carried as a regular part of the baggage train, thereby introducing a new factor in the defensive if not the offensive plans of war.

This machine was built expressly for Captain Glassford's experiments by the Norwalk Iron Works Company, of South Norwalk, Conn., from whom we obtained the photograph.

This compressor, which is only 5 ft. long and 2 ft. high, compresses the gas in three stages and is capable of working continuously, storing hydrogen in steel cylinders at a pressure of 2,500 lbs. The reduction of bulk in the gas at that pressure allows each cubic foot to occupy $\frac{1}{175}$ of the space occupied at atmospheric pressure. In other words, a small cylinder containing 10 cub. ft. of gas at 2,500 lbs. pressure would fill 1,750 cub. ft. of balloon space.

The machine as shown can compress 10 cub. ft. of free gas per minute. The mechanism is very simple and not liable to get out of order.

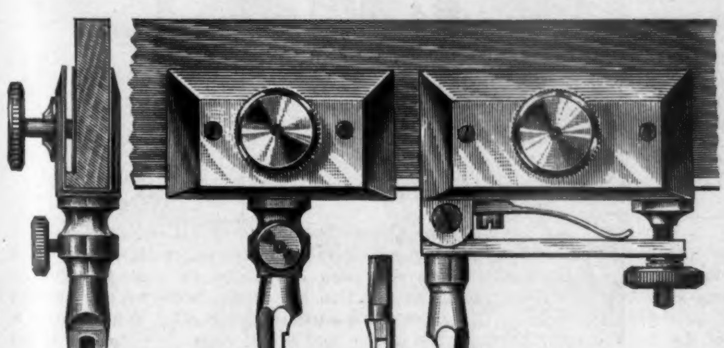
The gas is led into the larger cylinder shown at the front of the machine, through the larger flexible pipe shown at the right. It is then compressed to the space required by the second cylinder, the heat of compression being removed by the water jacket surrounding all three cylinders. The same operation is continued in the second and third cylinders and the gas discharged through the copper coil and connection shown in the engraving. By compressing in three stages, both excessive heat and excessive strains are avoided.

The machine is run by belt power, the pulley being only 32 in. in diameter. All three cylinders work upon the same trunnions, and the valves in all the cylinders are easily accessible. The hydrogen is compressed dry, thereby avoiding the additional weight which would arise from moisture in the gas and the danger of rotting the balloon by the presence of heat and moisture.

The Norwalk Iron Works Company also furnished the compressor used in firing the first dynamite gun, a pressure of 3,000 lbs. being guaranteed.

THE ALTENEDER BEAM-COMPASS.

A NOTICE of the catalogue of Messrs. Theodore Alteneder & Sons appeared in the last number of THE AMERICAN ENGINEER, which contained some criticism of the form of beam-compass which they make. It was said that "every time the screw is slackened which holds the sliding-head to the beam, the head becomes detached and must be held in position." This the Messrs. Alteneder say is not the case, and in evidence thereof have sent us one of the instruments of this kind which they make, and also a marked copy of their catalogue and an illustration of their instrument, which we publish herewith. From this it will be seen that their beam-compass consists of two sliding heads, the transverse sectional form of which is that of a letter U. In their catalogue it is said, "Each of these channels is provided with a light metal shoe, adjustable by means of a clamp-screw and guided by two steel screws. The shoe (as shown alongside of the letter *a* in the end view) does not reach to the bottom of the channel, but leaves space enough for a flange (also shown at *a*) on the lower edge of a hard-wood bar, used in connection with the beam-compass. It will thus be seen that the shoe, with its lower edge resting upon the flange, serves to hold the channel in position while it is slid along the bar, a turn of the clamp-screw firmly clamping it in any desired position. The wooden bars with flange are inexpensive, and add greatly to convenience in handling the instrument."



THE ALTENEDER BEAM-COMPASS.

From a more careful reading of this description, and an inspection of the engraving and the sample of the instrument which they have sent us, we see that our criticism was unjust, and that in its design and manufacture they have amply provided for the difficulty we erroneously and somewhat hastily concluded existed. All that we can find to say in mitigation of our hasty writing is, that the feature pointed out in the description, which has been quoted, is shown more clearly in the engraving above than it is in that published in the Messrs. Alteneder's catalogue. The instrument they make we find, on examination, is a very convenient one, is well made, and without the objections which we erroneously attributed to it.

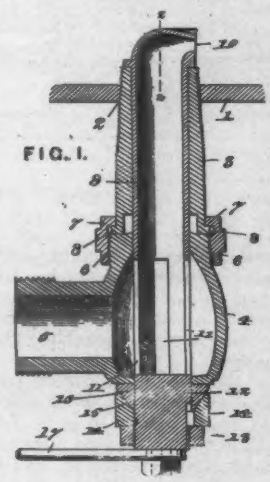
The objectionable binding of their catalogue the Messrs. Alteneder admit, and say will be obviated, but this is a matter of minor importance.

Recent Patents.

SMITH'S BOILER-CLEANING DEVICE.

MR. DIONYSIUS OLIVER SMITH, of Whistler, Ala., has patented the device represented by fig. 1 for cleaning locomotive or other boilers. It consists of what the inventor calls a cylindrical shell 3, which is screwed into the bottom of the shell of the boiler represented by 1. Inside of this shell is a rotatable tubular nozzle 9, which has a laterally deflecting discharge-nozzle 10, which is inside of the boiler. 5 is an inlet to which hose is connected and by which water is conveyed to the interior of the casing and by the openings 11 to the nozzle. 17 is a handle by which the nozzle can be turned, and as the stream of water is discharged from 10, it can be directed to different parts of the inside of the boiler. The nozzle is spirally twisted so as to distribute the water more generally.

FIG. I.



SMITH'S BOILER-CLEANING DEVICE.

This apparatus, we learn, has been applied to a number of locomotives on the Mobile & Ohio Railroad, and is giving great satisfaction. The patent is dated June 25, 1895, and is numbered 541,461.

HOBART'S STEAM-ENGINE.

The inventor of the engine, of which a longitudinal section of the cylinder is shown by fig. 2, describes it as follows:

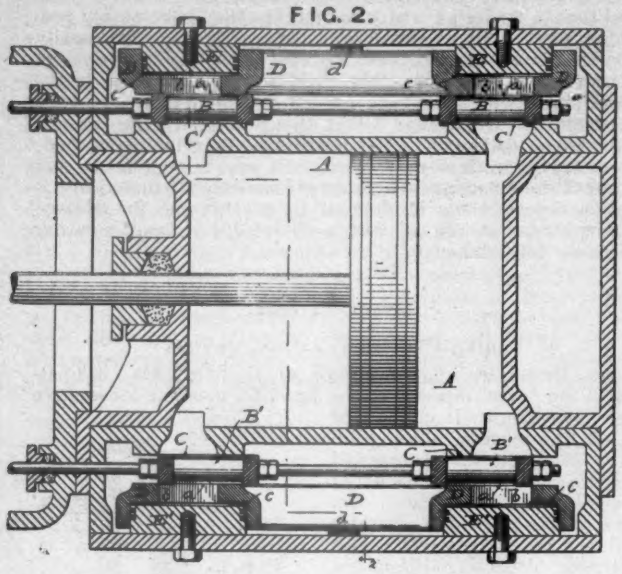
"The objects of the invention are, first, to produce an engine in which the valves shall be so nearly balanced as to be easily operated, and which shall still be held to their seats by enough unbalanced pressure to keep them always steam-tight; second, to produce an engine in which the valves shall be adapted for use as both steam and exhaust-valves interchangeably, the same patterns answering for both; third, to produce valves having four openings for inlet or outlet of steam, thus reducing the travel of the valve in this proportion; fourth, to produce a valve which may be easily adjusted to give the best possible distribution of steam under all circumstances; fifth, to produce an engine in which the valves will operate equally well at high and low speeds; and, sixth, to produce a simple practical construction well adapted to economical manufacture.

"*A* indicates the cylinder and *B B'* the valves, the latter working between the valve-seat *C* on one side and a corresponding seat on the relief plate *D* on the other side, thus giving four edges controlling the admission and exhaust of steam.

"The valve *B*, which is rectangular in outline with an open rectangular space, has long been in use, and is not claimed herein, the invention relating to the means employed for balancing it and to the application of such means to both admission and exhaust-valves.

"Relief plate *D* may be made, as in figs. 1, 2 and 3, of a single casting having two seats, one for each valve; or made as in the remaining figures, with each seat or end independent of the other. In all cases, however, it has on one face a seat or surface *a* in contact with the valve, and in said seat or sur-

FIG. 2.



HOBART'S STEAM ENGINE.

face an opening *b* having edges corresponding with the valve-seat on the cylinder. On the opposite face there is a larger opening *c* of any desired shape, but preferably cylindrical, to receive a piston *E*, which is fitted steam-tight in said opening by means of the usual packing-rings, or in any other suitable manner.

"Piston *E* is supported from the back by attachment to the chest cover, or in other suitable manner. The space below the piston is open to or in communication with the open space within the valve, and thence with that end of the cylinder to which the valve is applied; the piston therefore acting to relieve the plate *D* from the steam pressure over its area, and by making it larger or smaller, a less or greater degree of pressure between the working surfaces can be secured. When used with an exhaust valve, *B'*, the pressure within the cylinder usually exceeds that in the chest, and the piston *E'* should have an area a little in excess of the unbalanced area inclosed by the valve, the valve surfaces then being held in contact as before by a moderate force. Springs *d d* are inserted above the relief plate *D*, see figs. 1 and 2, and serve to keep the valve surfaces in contact when the valve is open and all of the parts are in equilibrium."

The inventor is Mr. Frank G. Hobart, of Beloit, Wis. His patent is No. 541,665, and is dated June 25, 1895.

NORDBERG'S FEED-WATER HEATER.

Fig. 3 is a vertical medial section of heater. Fig. 4 is a side elevation of the same, a section thereof being removed and a portion of the jacket or shell being broken away at its upper end. Fig. 5 is a vertical medial section of the base of the heater, taken in a plane at right angles to that of fig. 3. Its operation is as follows: Water entering the upper portion of lower chamber *A* through pipe *F* (shown in fig. 5) passes thence upwardly, as indicated by arrows, through the tubes *C C* and *D* into the upper chamber *B*, and, rising therein to the level of the upper end of pipe *E*, descends through said pipe and passes out of the heater through the branch *E'* to the boiler or other apparatus to be supplied. Steam entering the annular belt *a'* in the base through the inlet-opening a^2, therein expands and fills said belt on that side of the heater, transmitting a portion of its heat to the walls of chamber *A*, which in turn transmit it to the water contained therein. The steam being prevented by the partitions *J J* from passing around said belt *a'* to the outlet-opening a^3 on the opposite side of the heater, is compelled to rise in the space between the tubes *C* and shell *H*, and, passing upwardly and between said tubes, gives off its heat, which is transmitted through the walls of the tubes to the water contained therein. The partition-plates *K K* compel the steam as it rises above chamber *A* to pass upwardly and across the heater between the tubes *C C* and *D* before it can escape through the outlet-opening a^3, and thereby give off the greatest possible amount of heat which it contains to said tubes, to be transmitted thereby to the water passing through them. As the water enters the upper portion of chamber *A* the flow is checked, and any impurities contained therein are allowed to settle to the bottom, from which they may be readily removed through the hand-hole a^4. The water thus freed from a portion of the impurities contained therein passes from the upper portion of chamber *A* through tubes *C C* and *D* into the bottom of chamber *B*, where its flow is again retarded and remaining impurities are allowed to settle.

FIG. 4.

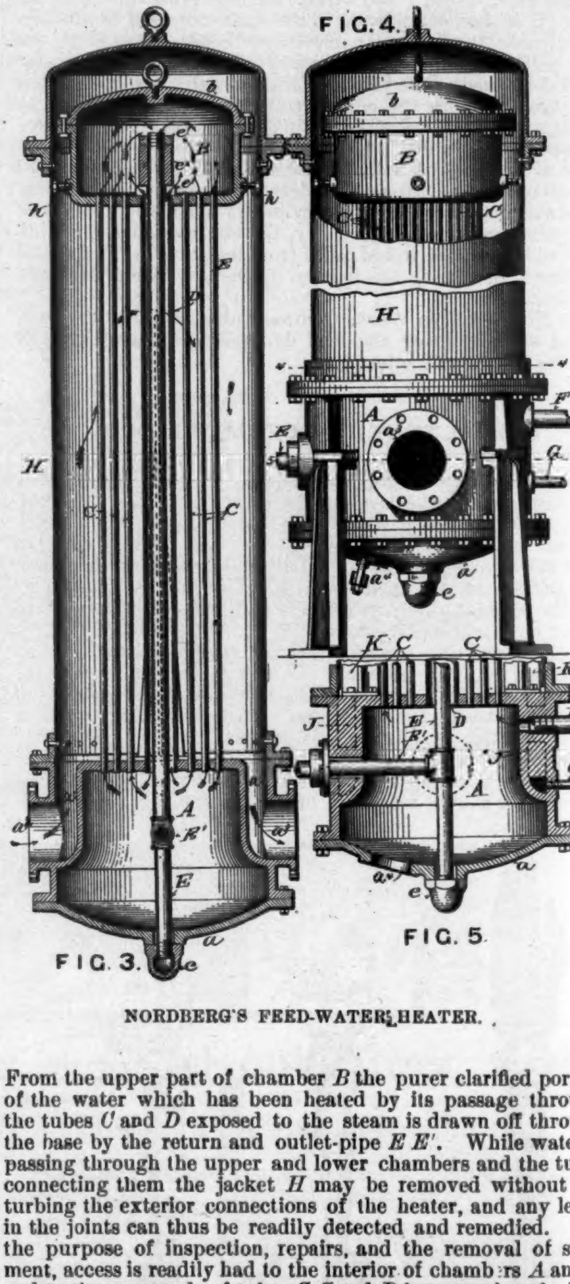


FIG. 3. FIG. 5.

NORDBERG'S FEED-WATER HEATER.

From the upper part of chamber *B* the purer clarified portion of the water which has been heated by its passage through the tubes *C* and *D* exposed to the steam is drawn off through the base by the return and outlet-pipe *E E'*. While water is passing through the upper and lower chambers and the tubes connecting them the jacket *H* may be removed without disturbing the exterior connections of the heater, and any leaks in the joints can thus be readily detected and remedied. For the purpose of inspection, repairs, and the removal of sediment, access is readily had to the interior of chambers *A* and *B* and to the open ends of tubes *C C* and *D* by removing the bottom *a* of the lower head and the cover *b* of the upper head. To remove the bottom *a* it is only necessary to unscrew the nut *e* on the lower end of pipe *E*, and take out the bolts by which the bottom is secured to the base. To remove the cover *b* it is necessary to first remove the shell *H*, and then the bolts by which said cover is attached to the upper head, but in neither case are the steam and water inlet and outlet connections with the base disturbed.

The inventor is Bruno V. Nordberg, of Milwaukee, Wis. His patent is dated July 2, 1895, and is numbered 542,004.

AERONAUTICS.

UNDER this heading we shall hereafter publish all matter relating to the interesting subject of Aerial Navigation, a branch of engineering which is rapidly increasing in general interest. Mr. O. Chanute, C.E., of Chicago, has consented to act as Associate Editor for this department, and will be a frequent contributor to it.

Readers of this department are requested to send the names and addresses of persons interested in the subject of Aeronautics to the publisher of THE AMERICAN ENGINEER.

THE WAR KITE.

EXPERIMENTS have been carried on for some time past at Pirbright with a new aerial apparatus to be used in the place of a captive balloon for military purposes. It is the invention of Lieutenant Baden-Powell, of the Scots Guards, and consists chiefly of a huge kite containing some 500 sq. ft. of canvas, which is assisted and steadied by other smaller kites. Not only has it been found, writes a military correspondent, that this apparatus can lift a man in moderate breezes, but it has lately been proved capable of doing so in a dead calm, the ropes being drawn along by men or by horses. The inventor delivered a lecture on the subject at the Royal United Service Institution on May 22, 1895.—*The Daily Graphic.*

AN OLDER FORM OF MILITARY KITE.

EXPERIMENTING WITH LIEUTENANT BADEN-POWELL'S APPARATUS.

ELASTICITY OF THE WING.

IT is well known that mathematicians have thus far been unable to compute satisfactorily the air reactions which take place under a bird's wing, more particularly in beating flight. They have made many calculations, but these did not agree with the facts. By figuring out the pressures generated on a plane (assumed to be the wing surface), at the known average speed of the down-beat of the wings, it was found that this calculated pressure was not equal to the weight of the bird.

Thus Mr. Drzewelcki showed, in his paper upon bird flight, read before the Paris International Congress in 1889, that a buzzard in full horizontal flight, weighing about 4 lbs., and with an aggregate wing surface of 2.15 sq. ft., would only generate, when beating his wings downward at an observed velocity of 6.56 ft. per second at the assumed centre of pressure, a sustaining air reaction of 0.40 lbs., which was of course quite insufficient to sustain the weight. Mr. Drzewelcki explained that the error in this case lay in neglecting the sustaining aeroplane reaction due to the forward speed, but the fact remains that calculations made for plane surfaces do not agree with the observed phenomena of bird flight.

A great many hypotheses have been advanced to account for this mystery. It has been suggested that the bird possesses some undiscovered skill, to increase the effect of his wing beats, by some "whip-lash" action at the end of the stroke, or to evade air resistance on the up-stroke by valvular action of the feathers The writers advancing these theories have generally seized upon some one ascertained fact, and sought to account thereby for the full mystery of flight.

Lilienthal, however, showed by experiments on models, and by subsequent practice in the field, that sustaining reactions were fully accounted for by the arched surface of the wing, and that much higher coefficients should be applied to air pressures corresponding to given velocities than is the case with planes. For beating flight, however, his data and premises are thought to be incomplete, and a number of papers have lately been published in Germany charging him with having neglected to consider some of the elements of final success.

Two of the latest among these papers refer to the elasticity of the wing and of the feather. They were written by Dr. George Berthenson, a Russian military surgeon, and by Captain H. W. L. Moedebeck, of the German artillery, and in charge of military ballooning.

Dr. Berthenson's paper was published in *Gegenwart*, January 26, 1895. It criticises Lilienthal's apparatus as imperfect, because its arched surfaces are unvarying in curvature, and do not change their shape in flight; refers to theories on this point previously advanced by C. Buttenstedt and by W. Berdrow, in books published in 1893 and 1894, and makes the broad claim that the propelling action of beating wings depends entirely upon their elasticity, no propelling effect being deemed possible with a wing absolutely rigid and fixed in outline.

The attempted demonstration of this dictum is rather hard to follow, because the author introduces considerations of what he terms "reserved curvature," bringing into play "reserved elasticity," and finally says that "the main requisite toward solving the flying problem is to determine the quantitative relations between the active force of man, the passive elastic force of the structure, and the work of gravity. This ratio is: Gravity, 1; elasticity, 2; muscular effort, 3."

Whatever this may mean, the practical application to Lilienthal's apparatus is contained in the two following extracts:

"Lilienthal says that birds' wings are arched, but he has not stated that this curving is elastic, and therefore not constant, so that under a certain combined action of gravity and of the muscular force of the bird, the curvature gradually vanishes. Buttenstedt demonstrates this, and shows that when the entire force of the bird is exerted the wing approximates to a plane surface. . . ."

"Lilienthal now intends to build beating wings of 14 sq. metres (150 sq. ft.) in area, because he now believes that wings

that merely soar do not possess propelling power. This will make his apparatus unnatural and unfit for use. Just as his placing high of the centre of gravity is dangerous and contrary to nature."

Captain Moedebeck's paper was published in the *Zeitschrift für Luftschiffahrt und Physic der Atmosphere* for May, 1895. It reviews Dr. Berthenson's paper, gives him a rap over the knuckles for the obscurity of his explanation, and propounds the inquiry as to what is the real use of the known elasticity of the wing and of the feathers.

This, as Captain Moedebeck believes, has a threefold object:

"1. To save strains on the muscles and the skeleton of the bird by gradually distributing the resistance of the air, produced by the wing through the muscular efforts of the creature.

"2. To produce horizontal propulsion, both in wing beating and in soaring.

"3. To prevent whirls and eddies in the escaping air, and the resulting friction, and to ensure the stability of the flight."

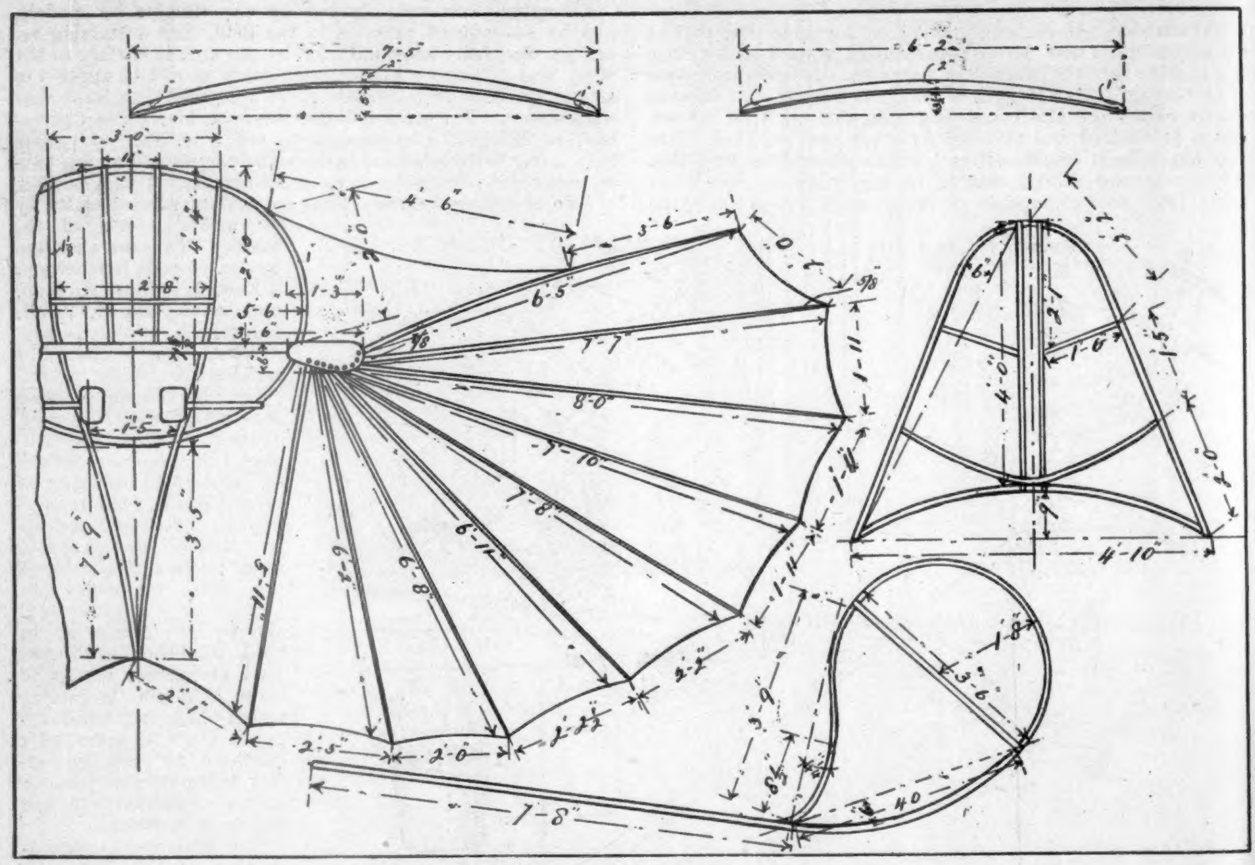
As to the first object, the author says:

produces a considerable effect, notwithstanding their small breadth."

In other words, the air escaping to the rear turns up the ends of the feathers, and presses against this as an abatement to drive the bird forward.

As to the third effect, or the prevention of eddies which might compromise the stability, the author says:

"Eddies are produced when separate layers of a fluid or gaseous medium suddenly come together. On the down-beat of the wing there is rarefaction above and compression below. The air endeavors to equalize its pressures; the denser air, escaping upward from a rigid wing, would produce whirls and eddies along its edges. If these were quite the same at all the edges, front and rear, there would be equilibrium. It is a condition, however, for all flying bodies that they shall be in unstable equilibrium. Absolutely rigid bodies, therefore, with an irregular escape of air, would be kept oscillating slightly, a fact which would make their use dangerous and difficult. The long primary feathers, however, have their points turned somewhat upward on the down-beat, and thus the pressure is able to escape continuously in spiral paths.



WORKING DIMENSIONS OF A LILIENTHAL FLYING MACHINE.

"It is easy to convince one's self by mere sense of touch of the correctness of the above statement, by alternately wafting up and down through the air a large primary bird feather, and an artificial feather of the same shape, but stiff and unyielding. The bird feather, through its elasticity, adapts itself, so to speak, to the resisting air, and the pressure is conveyed in a gentle and stable manner. On the contrary, with the stiff artificial feather, one feels very irregular and uncertain pressures. The resistance of the air tries to break the surface, which does not adapt itself to the strain."

In other words, as the author justly remarks, the elasticity of the wing acts, in this respect, as does a spring in a terrestrial vehicle.

As to the second, or propulsive effect, the author explains that this is chiefly obtained through the primary or rowing feathers, which are bent at their outer ends by the air pressure, so as to present inclined planes behind the line of flight, and he says:

"The pressure of the air generated by these feathers can therefore be decomposed into two components, one horizontal and propelling forward, and the other vertical and sustaining the weight. The great length of lever-arms of these feathers

This uniform escape of the air along the wing must essentially aid stability in flight. The elasticity of the feather thus facilitates a gradual passage of the air into its former condition, and the forces which would otherwise produce dangerous eddies are utilized in the interest of stability."

In other words, the elasticity of the feathers produces a more uniform escape of the compressed air, and so avoids unbalanced strains, which might compromise the equilibrium.

A LILIENTHAL FLYING MACHINE.

THE two half-tone illustrations herewith are front and back views of a soaring machine built by Herr Lilienthal for parties in England. The outline engraving is from a drawing, and shows views of the same machine and gives dimensions of its principal parts. The following particulars of its material and mode of construction will be interesting to many of our aeronautical readers:

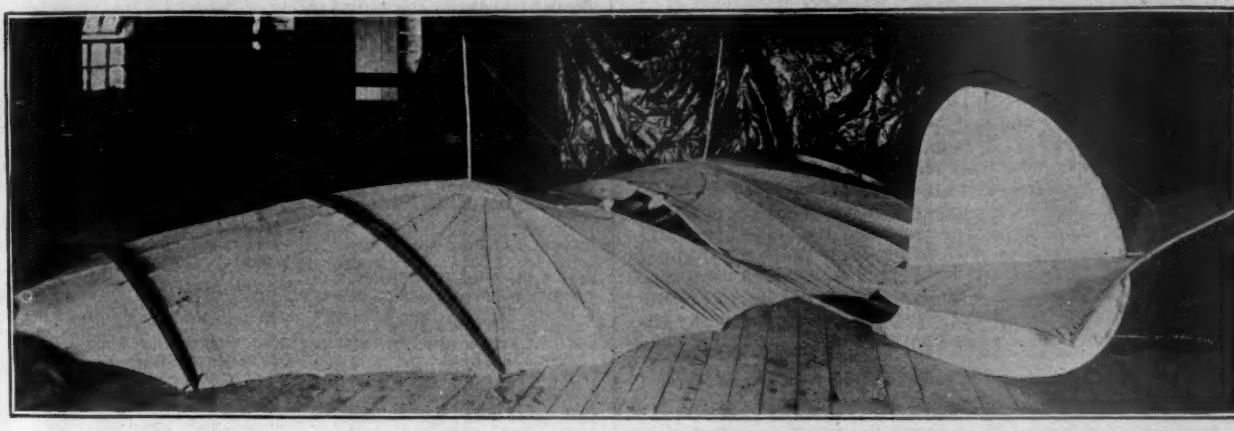
Surface of main wings	252 sq. ft.
" " horizontal rudder	$12\frac{1}{2}$ sq. ft.
" " vertical rudder	$10\frac{1}{2}$ sq. ft.

WEIGHT OF MACHINE.

Body	48 lbs.
Horizontal rudder	2½ lbs.
Vertical rudder	3½ lbs.
Total	54 lbs.

The framework is made of willow rods of about 1 in. in diameter with the bark peeled off. This is covered with calico sheeting, dressed, it is said, with an india rubber and naphtha solution to prevent wet from affecting it.

The main frame is made of willow wood, similar to that used for cricket bats, also the curved T pieces, which give the wings the hollow spoon shape. The wire stays are of galvanized steel 20 Birmingham wire gauge, with small screw lanyards for making all taut.



TOP VIEW OF A LILIENTHAL FLYING MACHINE.

The horizontal rudder is put at an angle of 10° with the horizon. In using the machine, the arms of the operator or aeronaut are passed through leather armlets, the hands grasping the cross-bar in front. Pads on the machine grip under the shoulders to help to support the weight of the body.

The note which we publish herewith announces that Mr. Lilienthal has discovered a method of controlling his machine which permits an operator with comparatively little skill to

A LILIENTHAL FLYING MACHINE SEEN FROM THE FRONT.

achieve flight. If this discovery fulfils its promise, we may not unreasonably expect in the not very distant future that soaring machines may be generally used as vehicles for diversion somewhat as bicycles are now.

It is understood that Herr Lilienthal has lately added a contrivance to his apparatus which increases its stability to such an extent that any unskilled person can easily learn its use. It is expected that this improvement will make air sailing a popular sport, and make the manufacture of such machines commercially profitable.

EXPERIMENTS ON WIND PRESSURE.*

THE subject of wind pressure is one on which our knowledge at the present day is not only limited, but exceedingly vague, and carefully made experiments, if but to investigate a single feature of the problem, are, therefore, of the greatest interest, and can hardly fail to add something new to our information. Mr. J. Irminger, C.E., Member of the Danish Society of Engineers, has determined, what it is believed no one before him has attempted to do, the amount of suction produced by a current of air striking a plane surface, or the surfaces of various bodies; and the results of his experiments form the subject of a paper with the above title, read before that Society in the early part of last summer. These results are remarkable in showing how very large a percentage of the total effect this suction is, not only through its action on the leeward side, but on the windward as well. In fact, when the angle at which the wind strikes a plane surface is small, nothing but suction is produced.

The practical importance of these experiments is evident; they throw considerable light on the subject of flight, which at present is engaging so much attention; and in structural designing they point out the way to more rational methods. We have hitherto considered the resultant of the pressure only, but if that of the suction is also taken into account, the final resultant is changed both in amount and direction. Thus in the case of a roof, given below, the resultant of suction and pressure will tend to lift, and not overturn it, which is in accordance with experience.

Experiments on wind pressure have usually been made by causing the body subject to the pressure to revolve in still air. The author's experiments were made with a fixed body

* Reprinted from the Proceedings of the United States Naval Institute.

exposed to a current of air. This current was obtained by making an opening into a large chimney 100 ft. in height and fitting to this opening a rectangular, horizontal wooden tube, 9 in. × 4½ in. in section, internally polished. The experiments were directed to ascertain the distribution of pressure over the surfaces both of planes (*i.e.*, solids of small thickness) and of bodies of various forms. Taking first the case of planes, the plane was represented in the experiments by two pieces of sheet iron, 4½ in. × 1⅛ in., placed 1/16 in. apart, and connected together along their edges so as to form a shallow closed box. To the interior of this box a pressure gauge was connected by means of a small pipe. A number of small holes were made in both faces of the box, of which one at a time was opened. By this means the pressure gauge registered the pressure at any desired point in the windward or leeward side of the box. The pressure-pipe formed an axle on which the box could be turned to any desired angle with the wind. By means of a valve in the wooden tube the velocity could be varied. The velocities employed were from 25 ft. to 50 ft. per second. Besides the plane above described, which occupied the full width of the tube (and may therefore be considered to represent in the open air a plane whose width is very great in proportion to its length measured in the direction of the wind), another plane was experimented with, measuring only 2⅛ in. × 1⅛ in. It should be remarked that the velocity of the wind was obtained from the observed normal pressures by reference to the ordinary tables. In the following tables, based on the experiments, it should be especially noted that at small angles of incidence the effect of rarefaction on the leeward side (showing itself as suction) causes practically all the pressure on the plane, and that at so small an angle as 5° this suction is over one-fifth of the total pressure (that caused by the wind direct, plus that caused by suction) on the same plane placed normally.

PLANE 4½ IN. BY 1⅛ IN. (FULL WIDTH OF TUBE.)

Angle of inclination of plane to direction of wind.	Proportion per cent. of total pressure produced on leeward side of plane, velocities of wind in feet per second being				Proportion per cent. of total wind pressure to pressure on same placed normally (average).
	49.5	48.5	34	31	
5°	100	100	100	100	23
10°	83	83	90	91	45
20°	76	81	89	86	48
40°	65	67	68	70	75
60°	60	63	65	63	90
90°	56	58	56	59	100

PLANE 2⅛ IN. BY 1⅛ IN.

5°	100	100	100	100	12
10°	100	100	100	100	26
20°	95	99	91	90	52
40°	78	76	70	74	74
60°	60	55	55	56	90
90°	48	43	44	46	100

The total pressures agree fairly well with those of Professor Langley, given in the Proceedings of the Royal Society for 1889. The variations are readily accounted for by the change in form, which has considerable effect, even with plane surfaces.

Doubtless in connection with the observed results at small angles of incidence, many readers will call to mind cases where, with a light beam wind and yards nearly square, a vessel under sail alone has made some phenomenal speed, unaccounted for except on the supposition that the real direction of the wind was from a point abaft its apparent direction. This, however, is no explanation at all, as will be seen by a little consideration. What is meant by the real direction of the wind is only relative; it is the direction with regard to a fixed point on the earth's surface. The apparent direction of the wind is a resultant of two motions, and is the true direction with regard to a moving object on the earth's surface—namely, the ship. There is no more reason to take into consideration the direction of the wind with regard to a fixed point on the earth's surface, than with regard to a fixed point in space, and this latter is manifestly absurd. But much of the result of trimming yards fine for winds abeam is readily accounted for by the suction.

Probably the high speed of the ice-boat is largely due to the same thing. The same is true of windmills.

It is observed that the bird holds its wing at an angle of 6° with the horizon; at this inclination the effect of the wind upon the under side of the surface is zero, while the suction acting in the upper side is equivalent to an upward pressure which sustains the bird. Moreover, the friction of the medium through which the bird moves is hereby reduced, and a current is produced acting toward the wing, and inclined upward at a small angle.

The following table gives the results of experiments on long prisms, placed with their axes at right angles to the wind. p is the total pressure on a long plane of width s placed normally to the wind, and of the same length as the prism. It has been shown that about 57 per cent. of p is due to rarefaction, causing suction on the lee side:

CROSS-SECTION OF PRISM.	Total Resultant Pressure in Direction of Wind.	Percentage Due to Rarefaction.
Square of side s (wind parallel to side).	0.95 p	43
" " " s " " " diagonal	0.79 p	76
Circle of diameter s	0.57 p	72
Rhombus, presenting an angle of 60° to the wind, length of side s	0.25 p	82
Equilateral triangle, side s (wind parallel to side)	0.59 p	42
Equilateral triangle, side s (presenting apex to wind)	0.42 p	86
Equilateral triangle, side s (presenting base to wind)	0.71 p	87

The following table refers to other than prismatic forms:

BODY UNDER EXPERIMENT.	Total Resultant Pressure in Direction of Wind.	Percentage due to Rarefaction.
Sphere	0.31 of total pressure on disk equal to great circle	77
Sphere distorted by elongation in the direction of the wind to double the diameter in length, ends pointed and symmetrical	0.08 of total pressure on disk equal to cross-section	93
Cube of side s (wind parallel to edge)	0.80 of total pressure on disk, equal to face	22
Cube of side s (wind parallel to diagonal of face)	0.66 of total pressure on disk, equal to face	55
Cylinder of height equal to diameter (wind perpendicular to axis).	0.47 of total pressure on square disk, equal to section through axis	50
Pyramid, square base of side h, height h (wind parallel to side of base)	0.78 of total pressure on disk, equal to maximum section perpendicular to wind	37
Pyramid, square base of side h, height h (wind parallel to diagonal of base)	0.55 of total pressure on disk equal to maximum section perpendicular to wind	55
Cone, height = diameter of base = h (wind parallel to base)	0.38 of total pressure on disk, equal to maximum section perpendicular to wind	50

The method used with these bodies is similar to that described for plane surfaces; the different bodies are hollow and made of thin sheet iron; they are about 4½ in. long, and provided with three holes in a row in the middle of one side. A hollow axis passes through the centre, and communication is made with the pressure gauge in the same manner as before.

In the case of the cylinder, which was examined by boring a single hole in it and revolving it gradually through 360°, it was found that pressure existed only between 0° and 35°, when the effect became a suction. Similar results were found for the sphere.

Models were also experimented with representing buildings with roofs of various forms, and diagrams are given showing the distribution of pressure over leeward and windward sides. In all cases rarefaction on the side is quite as important a factor in the actual resultant force on the building as is the positive pressure on the windward side. The case of the pitched roof making angles of 45° with the horizontal on which a horizontal wind acts at right angles to the ridge is particularly worthy of note, and furnishes some food for thought. The normal pressure on the lee side due to suction is more than three times as great as that on the weather side. The resultant pressure on the two faces (neglecting the walls of the building) is inclined upward, and is about three and one-half times as great as that on the weather side. On the weather side the pressure is greatest near the lower edge, diminishes uniformly, and becomes a suction near the ridge.